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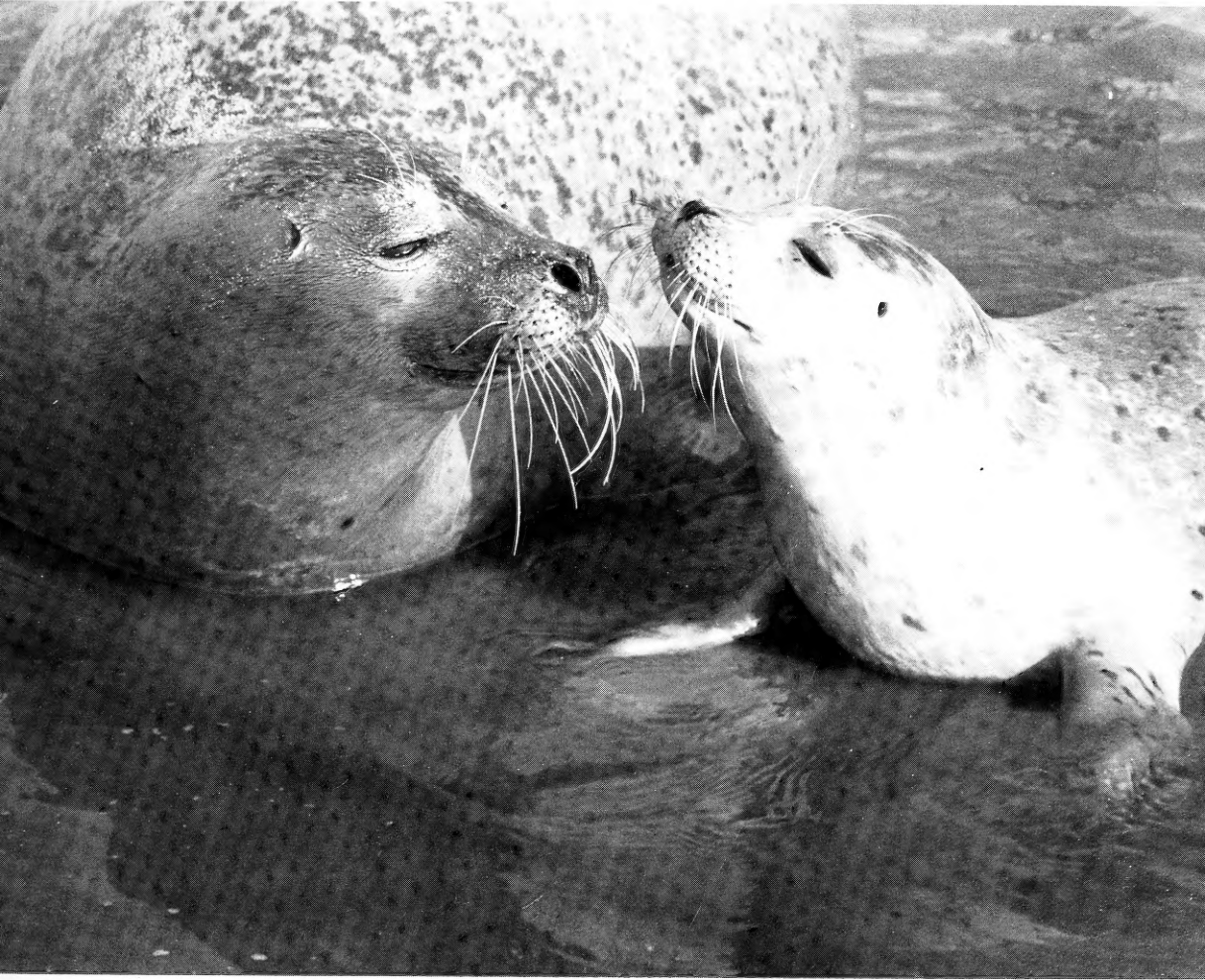
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Cover: Harbour Seals, *Phoca vitulina*, photographed at Miquelon (provided by Deane Renouf), see article by Davis and Renouf pp. 1-5.

The Canadian Field-Naturalist

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Social Behaviour of Harbour Seals, *Phoca vitulina*, on Haulout Grounds at Miquelon

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Davis, M. Benjamin, and Deane Renouf. 1987. Social behaviour of Harbour Seals, *Phoca vitulina*, on haulout grounds at Miquelon. Canadian Field-Naturalist 101(1): 1-5.

A breeding colony of more than 700 Harbour Seals (*Phoca vitulina*) on the French island of Miquelon was observed during 1982. Behavioural interactions among different age and sex classes were documented, and the spatial organization of seals on the haulout grounds was assessed photographically. The study revealed a consistent hauling out pattern, and a predictable arrangement of animals on the beach, with a high degree of site tenacity. Our observations are discussed in light of existing theories of the social organization of Harbour Seals.

Key Words: Behaviour, Harbour Seals, *Phoca vitulina*, haulout grounds, Miquelon.

The terrestrial behaviour of Harbour Seals, *Phoca vitulina*, is not well understood because it is usually difficult to approach seals while they are out of the water without causing a disturbance. Their typical reaction to being disrupted is to flush off the beach or exposed rocks they use as haulout grounds. This problem is compounded at some locations where they do not haul out in the same place over successive days (Boulva 1973; Mansfield 1967), making it impossible to observe the same group of animals for a sufficiently long time to see any behavioural consistencies. The breeding colony of *Phoca vitulina* on the island of Miquelon provided the opportunity to reduce the problems normally associated with observation of this species. We were able to watch the animals from as little as a few meters away, and since study from close range is unusual, we report some novel observations of the seals' behaviour. These data have also allowed some insight into the possible nature of their group structure dynamics and organization.

Methods

The breeding colony of *Phoca vitulina* in the Grand Barachois on the French Island of Miquelon off the south coast of Newfoundland was observed during 1982 from 6 May to 5 July and from 31 July to 17 August. A full description of the study site can be found in Renouf et al. (1983). With each falling tide, a series of sand flats become exposed in the centre of the

Barachois where six to eight hundred Harbour Seals and approximately 60 Grey Seals haul out (see Figure 1). The seals are forced to abandon the sites near high tide.

Prior to the arrival of the seals in 1982, blinds elevated 1.75 m at floor level were erected on the sand flats in the vicinity of the four sites where seals typically formed terrestrial groups (Figure 1). About two weeks later, groups of seals began to haul out at one or more of these locations.

For the last two weeks of May and the first week of June 1982, the paucity of seals at other sites restricted watches to the blind at site B. Once groups started to assemble at site C, observations were made primarily from that site with one or two visits per week to site B. The seals abandoned sites C and D after 5 July 1982. During the moult in August, observations were undertaken exclusively at sites A and B since groups did not form at sites C or D.

Before the seals began to haul out at site C, a 200 m by 30 m grid in 5 m by 5 m squares was anchored in the sand. Grid markers 30 cm long with a conical base were constructed from 3 mm gauge aluminum wire topped with fluorescent surveyor's tape. They were buried in the sand so that only the tape protruded. Ninety-five percent of them remained in place for the duration of the study even though they were submerged during each rising tide. The grid was used primarily to determine site fidelity of the group and of

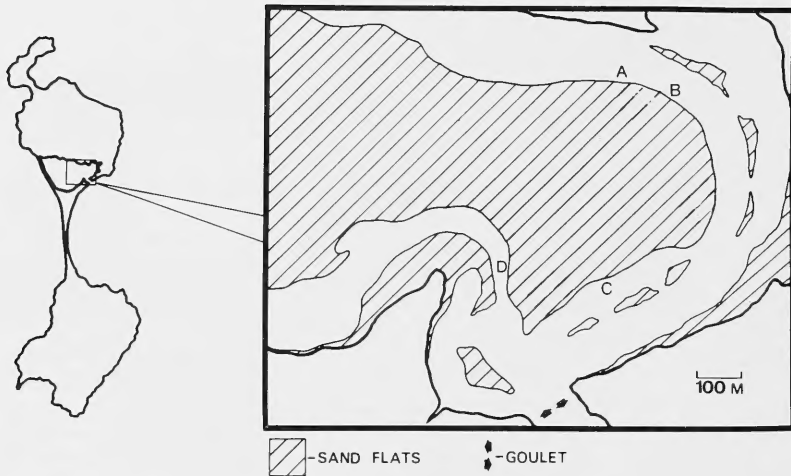


FIGURE 1. The Grand Barachois of Miquelon showing the four haulout sites (A, B, C and D) of the Harbour Seals. The Goulet de Langlade is the only connection between the Barachois and the sea.

any identifiable individuals. The grid was also used to measure from photographs the distances that separated animals in a group.

Observations were undertaken during every daylight low tide cycle except when weather conditions were so severe that the seals did not haul out. Shortly after the tide peaked, the observer was transported by boat to a blind and remained there until the following rising tide or until the seals were prematurely dispersed by a disturbance. Observations of the behaviour of the seals were tape recorded and later transcribed.

One adult male, one female and ten pups were marked with dilute red marine paint, applied by lobbing a paint-filled chicken egg into the seal herd from the water. The group always flushed to the water after an egg was thrown, thus limiting the number of animals marked. Other methods of marking the seals with various substances met with failure. Some animals were recognizable from unique scarring patterns or coloration. However, most animals were distinguished on the basis of sex and age class as adult male, adult female, female with pup, juvenile, pup, and weaned pup. Adults were relatively easy to sex from genital patterns, but it was difficult to be as certain with the younger seals.

Composite photographs of the herd were taken at two to five minute intervals during the formation of the group, and at thirty to forty-five minute intervals

once the animals had settled. Two to eight frames were required to cover the entire group at one time. Composites were constructed from contact sheet prints. Sex (where possible), age class, and group numbers were extracted from the composites by examining them with a Nikon compound dissecting microscope at 7x magnification. Colour slides of the group were examined directly with the dissecting microscope for the same information. Visual counts of the numbers of seals in a group were taken at the same time as the herd was photographed to corroborate the photographic counts.

Results

During 1982, a total of 136 group formations were observed. At site C the seal herd always hauled out so that most of the animals lay on the same portion of the grid over successive days. Animals never settled outside its northwest border, or any more than 10 m outside its southeast border. Some identifiable animals appeared to be relatively site-specific over days. The first adult male observed settling on site C, recognized by a unique scarring pattern on the left side of his neck just posteroventral to his ear, used the same grid location (± 2 m) over six successive days and was consistently the first animal to establish himself at the site. One of the few adult males which was paint-marked settled four times at one grid location although not over successive days. On

another occasion, he returned to the same position on the beach after the entire herd had been flushed into the water three times.

The pattern of group formation along the sand flats was consistent from May to July. In the absence of any disturbance, group formation usually proceeded after a "critical depth" of water was reached. This depth, as determined from photographs or measured with reference to the legs of the blinds, was approximately 40 cm; however, when the only seals present were females with pups, the critical depth was 25 cm. Critical depth did not apply to younger animals since they did not haul out until after a number of adults had established themselves and the sand flats were only slightly submerged. It was not possible for a seal to settle on the sand flats before the critical depth was achieved. Once the adults could reach the substrate with their abdomens, they would assume a "U"-shaped posture. This stance involved the seal rolling on its side or remaining on its belly and elevating its head and hind flippers well out of the water, physically forming a flattened 'U' (or crescent) shape.

A "critical number" of adults was necessary before group formation would begin in earnest. This critical number was defined as that number of adults required on a site before a terrestrial group would increase linearly in size. Throughout the breeding season, the critical number was four adults for all sites. Seals forming the critical number at site C arranged themselves on average 17.26 m apart ($s = 15.30$; $N = 114$). Once these four seals settled on the sand, the group size never reverted to fewer than four animals, unless there was a disturbance. Prior to the establishment of the critical number, from one to three seals would be transient visitors to the site, staying only briefly. Juveniles, yearlings and weaned pups were never observed as members of the critical number. If the critical number was not present at any time after the critical depth for a lactating female (25 cm) had occurred, seals that attempted to settle in the shallows or on the sand did not remain in place for longer than five minutes and a group did not form.

At sites A and B, adult males and lactating females formed the critical number. During May and the first sixteen days of June 1982, lactating females formed the critical number at site C, and after 16 June until this site was abandoned on 5 July, adult males primarily formed the critical number.

Juveniles were never seen to initiate a terrestrial group. Their journeys into the shallows prior to critical depth being achieved were usually in association with a female and pup. Juveniles occasionally settled on their own in small groups after a disturbance but their placement on the sand was

never deeper than 2 m inland and they typically left within 1 to 5 minutes. On one occasion, seven juveniles formed a group and dispersed four times in succession.

Spacing measurements during the breeding period were obtained from the composite photographs of the groups, supplemented by field observations. At sites A and B, the distance separating pregnant females from other seals was on average 12.38 m ($s = 3.59$; $N = 83$). Lactating females maintained average distances of 4.66 m ($s = 0.92$; $N = 50$). Other adults and juveniles maintained distances of 0.94 m ($s = 0.57$; $N = 200$) from all but pregnant females. This resulted in the formation of groups with a central concentration of adult males, females with pups and juveniles, surrounded by pregnant females and/or females with pups born during that tide cycle. Many of the females who delivered pups away from the main congregation of seals returned to the water with their newborns and joined the end of the group that was settled on the sand closest to their birthing place. Others remained where they had pupped until they were dispersed with the rising tide. Juveniles and solitary adults settled 2.04 m ($s = 1.01$; $N = 200$) from others and pups without conflict. Therefore, the gaps created by females and pups were filled by later arriving juveniles or solitary adults.

During the moult, groups consistently formed at least 250 m away from the blinds, necessitating the use of binoculars for observations. The distance separating the blind from the groups also made it impossible to obtain photographs that could be used to determine the size of the spaces that separated the seals. However, based on an adult seal length of 1.75 m, it appeared that both sexes and all age classes (except weaned pups who did not join the groups) maintained a distance of 0.5 m or less throughout the moult period without any sign of conflict.

Before weaning, the most intense conflicts always included lactating females. Females with pups were involved in 62.8% ($N = 103$) of recorded aggressive encounters. Of these, 57.3% occurred between two lactating females, 35.0% with juveniles and 7.7% with adult males. During and after weaning, conflicts between adults of both sexes were the most intense. Pairs of nonlactating adults were involved in 39 fights (23.6%); 36 of these occurred after weaning. Eleven involved pairs of adult males, in which case conflict reached a level of severity where lacerations resulted. Conflicts between other seals were never as damaging. Their fights also lasted longer than any others, with durations ranging between 30 and 120 seconds ($N = 11$). All of the observed conflicts started and ended in deep or shallow water. Fights did not take place between males on land nor did males arrive or

leave terrestrial groups to engage another male in battle. Conflicts ended when one male swam away from the other and settled in the shallows or on the sand or was lost to sight. Chasing was never observed as a component of fighting. The remaining conflicts involved an immature animal and an adult ($N = 11$; 6.7%) or two immature seals ($N = 12$; 7.3%). The number of agonistic encounters was not significantly different over successive segments of the breeding season ($F = 1.31$, $df = 3.24$, $p > 0.05$), although the participants changed from primarily adult female to adult male at the time of weaning. Lactating females were involved in 62.8% ($N = 165$) of the encounters recorded. Adult-adult, adult-juvenile, and juvenile-juvenile conflicts accounted for the remaining number.

Discussion

Controversy exists in the literature regarding the nature and extent of the social organization of Harbour Seals. There are many reports which suggest minimal structure. Scheffer and Slipp (1944) described them as "gregarious on land, but as a rule solitary when foraging". A similar situation was described by Bishop (1968) in the Gulf of Alaska, and by Button (1975) for *P. v. concolor* at Miquelon. Knutson (1974) postulated that the Harbour Seal formed "societies of strangers" on land, and that associations were never of an enduring nature. In contrast, Wilson (1974, 1978) and Wilson and Kleiman (1974) have suggested that complex interactions occur among juvenile seals at terrestrial sites in the Gulf of Maine and in the Shetlands, though they proposed an adult social organization in which males do not compete to mate with females. Nonetheless, they believed that there is a long-term network of social relationships, and attributed the durability of these relationships to the long period of immaturity. Wilson (1978) and Wipper (1975) also proposed that the terrestrial herd is structured socially into subgroups characterized by adult sentries. Wilson further suggested that the groups were cohesive in the water and took part in co-operative feeding activities. Sullivan (1982) described a dominance hierarchy where access to prime space on rocky ledges was determined by the size and sex of the seal, with adult males dominating all other age classes.

The results of the present study do not corroborate many of the conclusions of earlier investigations of the social behaviour of this species. Wilson's (1978) notion that groups form as a carry-over from group foraging in the water seems unlikely since most evidence suggests that Harbour Seals forage individually (Scheffer and Sperry 1931; Rae 1973; Renouf et al. 1981). The lack of male-male

competition reported by Wilson (1974) was not the case at Miquelon. Male-male aggression, which might reflect some form of mate competition, was very prevalent around the time of weaning. All such conflicts between adults occurred in water at the time when copulation was supposedly occurring.

We found no evidence of the kind of dominance hierarchy proposed by Sullivan (1982), perhaps because at Miquelon there was enough space on the sand flats to accommodate all of the animals. Sullivan reported that adult males were the first to settle on the rocks and would occupy the highest ground which was most protected from surf action. Lower and less desirable haulout ground was used by progressively smaller animals, resulting in a vertical stratification of seals according to size and sex. We observed both adult males and females hauling out before younger seals but there appeared to be no overt competition for particular places on the beach.

The seals at Miquelon were more than "loosely gregarious" in the sense intended by Scheffer and Slipp (1944), Bishop (1968), Button (1975) and Knutson (1974), since there was a predictable spatial arrangement of the seals on the beach and a preference for four specific sites in the Grand Barachois, even though kilometers of secluded sand beaches surround the exterior of the island. Such site fidelity might suggest (as is the case with other pinnipeds which have identifiable social structures) that the seals reunite during the breeding season to carry out the pupping and mating rituals in a manner dictated by the rules of their social organization.

Each of their traditional haulout sites was adjacent to the few places where water was always deep enough to swim in and offered an escape route even at the lowest point of the tide. This factor could suggest that it is escape from human disturbances rather than any social organization that leads to their site fidelity, and grouping occurs as a consequence of the limited number of sites from which escape is practicable. However, if this were true, it is difficult to comprehend why they did not use the exterior beaches to which humans have virtually no access and which are not flooded during each tide cycle. Perhaps the females require a sheltered place to give birth and nurse their pups. On Sable Island, Nova Scotia, pregnant female Harbour Seals are known to travel more than 1 km overland to pup on the shores of inland lakes (Renouf and James 1975). The Barachois offers haulout grounds surrounded by relatively calm waters without surf action.

Though the attachment of the seals to specific haulout locations may originate in response to some physical requirement of the animals, the structure of the group which then forms there might be a function

of their social needs. Perhaps the males settle on the same site as the females to be close enough to monitor their breeding condition. At Miquelon, males started positioning themselves in the vicinity of females who were close to weaning their pups and presumably about to come into oestrus. The manner in which the rest of the group distributed itself on the sand was related, at least in part, to aggression which appeared to maintain distances between animals and play a role in arranging age classes and sexes. The consistency of the arrangement of the seals on each haulout ground suggests that it was functional. The large gaps between nursing females may have reduced the chances of conflict and confusion over the ownership of pups.

Although the results reported here are not in full agreement with other detailed studies of Harbour Seal social behaviour, they do suggest that some form of social organization exists. The only way to identify the nature of this social structure is to observe the behaviour of a herd in which most animals are individually recognizable.

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Literature Cited

- Bishop, R. H.** 1968. Reproduction, age determination and behaviour of the harbour seal, *Phoca vitulina*, in the Gulf of Alaska. M.Sc. thesis, University of Alaska, College, Alaska.
- Boulva, J.** 1973. The biology of the harbour seal in eastern Canada. Ph.D. thesis, Dalhousie University, Halifax, Nova Scotia.
- Button, C. E.** 1975. Environmental and biotic influences on the haul out behaviour of *Phoca vitulina* (Linnaeus 1758) and *Halichoerus grypus* (Fabricius 1791). M.Sc. thesis, Memorial University of Newfoundland, St. John's, Newfoundland.
- Knudston, J. R.** 1974. Observation of the harbour seal in Humboldt Bay, California. California Fish and Game 63: 666-670.
- Mansfield, A. W.** 1967. Distribution of the harbour seal, *Phoca vitulina* Linnaeus, in Canadian Arctic waters. Journal of Mammalogy 48: 249-257.
- Rae, B. B.** 1973. Further observations on the food of seals. Journal of Zoology 169: 287-297.
- Renouf, D., L. Gaborko, G. Galway, and R. Finlayson.** 1981. The effect of disturbance on the daily movements of harbour seals and grey seals between the sea and their hauling grounds at Miquelon. Applied Animal Ethology 7: 373-379.
- Renouf, D., J. Lawson, and L. Gaborko.** 1983. Attachment between harbour seal mothers and pups. Journal of Zoology 199: 179-187.
- Renouf, D., and H. James.** 1975. Navigation in harbour seals. Pages 247-253 in Biology of the seal. Edited by K. Ronald and A. Mansfield. Rapports de Procès-verbaux des Reunions. Conseil International Permanent pour l'Exploration de la Mer 169.
- Scheffer, V. B., and J. W. Slipp.** 1944. The harbour seal in Washington State. American Midland Naturalist 32: 373-416.
- Scheffer, V. B. and C. C. Sperry.** 1931. Food habits of the Pacific harbour seal, *Phoca richardii*. Journal of Mammalogy 12: 214-226.
- Sullivan, R.** 1982. Agonistic behaviours and dominance relationships in the harbour seal *Phoca vitulina*. Journal of Mammalogy 63: 554-569.
- Wilson, S. C.** 1974. Juvenile play of the common seal *Phoca vitulina vitulina*, with comparative notes on the grey seal, *Halichoerus grypus*. Behaviour 48: 37-60.
- Wilson, S. C.** 1978. Social organization and behaviour of the common seal *Phoca vitulina concolor*, in Maine. Final Report to the Marine Mammal Commission. Report Number MMC-76/10.
- Wilson, S. C., and D. G. Kleiman.** 1974. Eliciting play: a comparative study. American Zoologist 14: 341-370.
- Wipper, E.** 1975. Ekologie des Seehundes, *Phoca vitulina* (Linne, 1758) an der niedersächsischen Nordseeküste. Saugtierkunfliche Mitteilungen 23: 32-63.

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Observations of Killer Whales, *Orcinus orca*, in Western Alaska: Sightings, Strandings, and Predation on Other Marine Mammals

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Lowry, Lloyd F., Robert R. Nelson, and Kathryn J. Frost. 1987. Observations of Killer Whales, *Orcinus orca*, in western Alaska: sightings, strandings, and predation on other marine mammals. *Canadian Field-Naturalist* 101(1): 6-12.

Recent observations confirm that Killer Whales (*Orcinus orca*) occur off the coast of western Alaska from at least Bristol Bay to north of Point Barrow. They have been seen in drifting ice in spring and in open water during summer. Three strandings involving 10 animals that occurred in 1982-1984 in the area from Nunivak Island to Norton Sound are described. Observations of Killer Whales chasing a Minke Whale (*Balaenoptera acutorostrata*) aground in Unalaska Bay, and of Killer Whales eating a Gray Whale (*Eschrichtius robustus*) in the Chukchi Sea are reported. The marine mammal prey of Killer Whales in the area include Gray Whales, Minke Whales, Walruses (*Odobenus rosmarus*), Beluga Whales (*Delphinapterus leucas*), and seals (Phocidae).

Key Words: Killer Whales, *Orcinus orca*, distribution, predation, strandings, Minke Whale, *Balaenoptera acutorostrata*, Gray Whale, *Eschrichtius robustus*, Walrus, *Odobenus rosmarus*, seals, Phocidae, Beluga Whale, *Delphinapterus leucas*.

Killer Whales, *Orcinus orca*, are one of the most widely distributed toothed whales, being found in all oceans and major seas (Dahlheim 1981). In some regions they have been comparatively well-studied, due either to their proximity to population centers (e.g. in Puget Sound, Washington) or to their importance in commercial harvests (e.g. off Japan and Norway, and in Antarctic waters). There are few published data available on Killer Whales in Alaskan waters, with the exception of some information on distribution and abundance in the Gulf of Alaska and Bering Sea (summarized in Braham and Dahlheim 1982; Leatherwood et al. 1983a, b). In this paper we report recent observations of Killer Whales in the Bering and Chukchi seas.

Methods

Our information on Killer Whales comes from two principal sources. The first are sightings made by the authors and other researchers during various shipboard and aerial studies of marine mammals. During these studies it has been common practice to record all observations of marine mammals and to deviate from scheduled activities, when necessary, in order to investigate particularly significant or unusual events. Our second source is a network of informants who live and work along the coast of the eastern Bering and Chukchi seas. These informants, consisting mostly of biologists, fishermen, and subsistence hunters, commonly report observations of marine mammals on standardized sighting cards which we have distributed, or by contacting local offices of the Alaska Department of Fish and Game.

Whenever possible, significant reports are investigated and confirmed. Killer Whales are generally conspicuous and easy to identify. Their appearance is distinct from that of other similar-sized cetaceans occurring north of the Aleutian Islands, and we therefore consider our sightings to be very reliable.

Where possible, ages of stranded animals were determined by counts of dentinal annuli, which were done by personnel at the National Marine Mammal Laboratory, Seattle, Washington.

Results

Sightings

Sightings of Killer Whales occurred in four general areas: the ice front and ice remnants of the Bering Sea; inner Bristol Bay; Bering Strait; and the Chukchi Sea (Figure 1).

In spring 1976-1979 we participated in seven research cruises investigating the ecology of ice-associated pinnipeds in the Bering Sea. On those cruises, other than occasional sightings near Unimak pass, we never sighted Killer Whales in open water south of the pack ice. On five occasions whales were seen in the ice (Table 1), generally within 10 km of open water in ice coverage ranging from 3 to 7 octas [or eighths]. Group sizes ranged from 1-12 animals. One additional sighting of 4-5 whales about 5 km south of the ice edge was made on 2 June 1985.

All other Killer Whale sightings were made during the open-water season: two sightings in inner Bristol Bay, two near Bering Strait, and four in the Chukchi Sea (Table 1). The largest was a group of about 20 seen in August 1976 just south of Bering Strait. The group

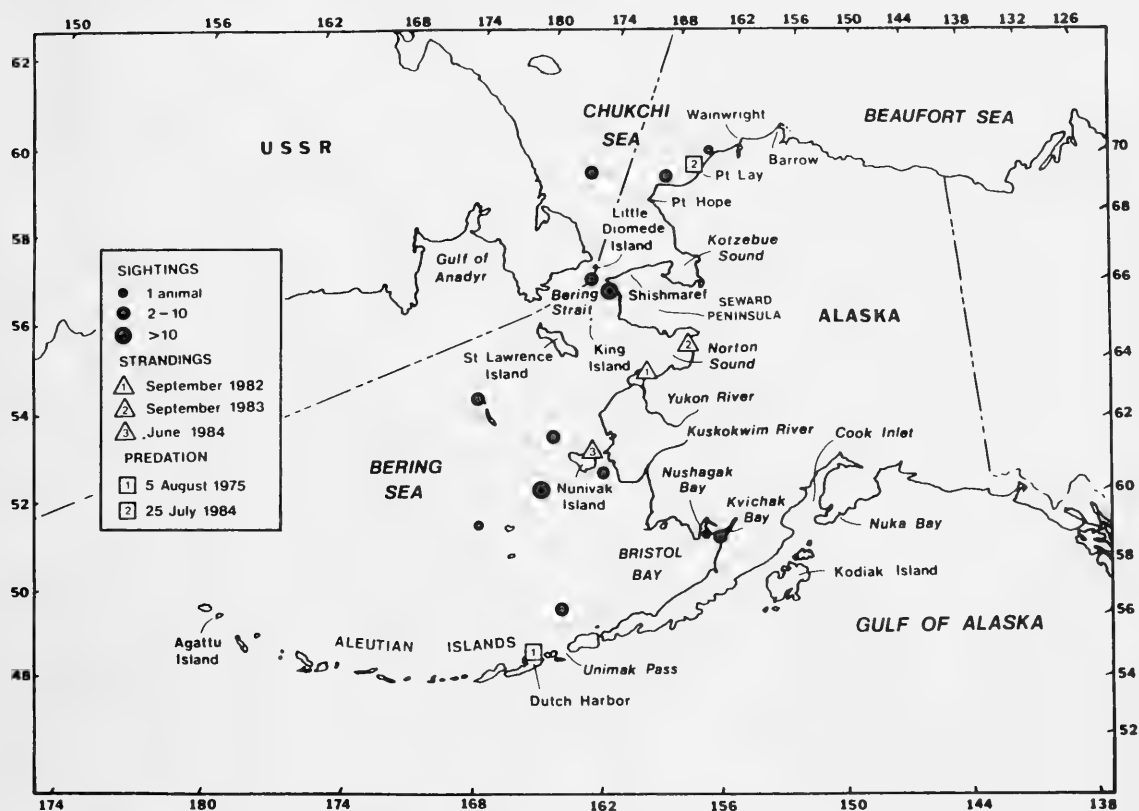


FIGURE 1. Map of Alaska showing the locations of sightings, strandings, and observations of predation by Killer Whales in the eastern Bering and Chukchi seas.

of six sighted on 26 July 1984 in the Chukchi Sea included at least one of the same animals seen on the previous day, a large male with a broad, shallow notch in the lower portion of the posterior edge of the dorsal fin. That animal had moved a minimum of 124 km in 17 hours.

Strandings

The best documented recent stranding occurred in early September 1982 at one of the northern mouths of the Yukon River near the village of Kotlik (Figure 1). We were notified of the stranding on 13 September, but inclement weather prevented us from investigating it directly. A resident of Kotlik, Mr. Joseph Mike, visited the site twice in September and provided the following detailed description.

On 10 September, two dead female Killer Whales were located just inside an unnamed slough which connects the Kvichavuk River to Pastol Bay. Two

other whales (presumably also dead and reported to be males) were grounded about 2 km offshore in a shallow portion of Pastol Bay. The females were examined for wounds but none were found. The other whales could not be reached. On 23 September the females had been moved by the tide to locations farther up the slough. The other two whales could not be located. One of them was later sighted about 11 km to the east. The females were measured and photographed, and teeth were extracted. The overall lengths and ages were 5.9 m and 18-20 years old, and 6.3 m and 17 years old, respectively. The fact that there was no evident cause of death puzzled our informant, since "there was enough water in the slough to keep them alive." Mr. Mike also stated that this was the first report of Killer Whales found dead along the Yukon Delta and that Killer Whales have been seen rarely in the vicinity of the Yukon River but never before in Pastol Bay.

TABLE 1. Sightings of Killer Whales in the eastern Bering Sea, Bristol Bay, and Chukchi Sea 1976-1984.

Date	Local Time	Location	Total No. of Whales	Setting	Comments
21 March 1976	0620	Bering Sea Ice Front 55°33'N 166°41'W	2	3 octa ice; small, loose floes	female with very small calf
17 April 1976	0755	Bering Sea Ice Front 57°09.4'N 172°08.1'W	1	in small polynya (300 × 200 m) in 7 octa ice	male
26 March 1977	0715	Bering Sea Ice Front 58°27.9'N 169°29.1'W	12	in polynya, swimming north and into the ice	1 large male, 3 small animals
24 May 1977	1400	Bering Sea Ice Remnant 60°31.5'N 174°21.9'W	2	in 4 octa ice	
29 May 1977	1515	Bering Sea Ice Remnant 60°25.9'N 168°56.3'W	9-11	moving through 3 octa ice	3 large males and 6-8 medium-sized animals
2 June 1985		Bering Sea Ice Remnant 59°58'N 164°55'W	4-5	about 5 km south of ice edge	
24-30 June 1981		Bristol Bay-Nushagak Bay 58°38'N 158°22'W	1	open water	sighted 4 times, apparently feeding on salmon
22 May 1984		Bristol Bay-Kvichak Bay 58°32'N 157°44'W	8	open water	2 large males and 6 medium-sized animals
21 August 1976	1310-1520	Bering Strait 65°38'N 168°15'W	±20	open water	sighted several times, at least 3 large males and 3 calves in the group
20 August 1983	1400	Bering Strait 65°46'N 169°59'W	2	open water	2 males
25 August 1976	1125	Chukchi Sea 68°18.2'N 172°32'W	3	open water	1 male, 2 medium-sized animals
11 July 1981	1919	Chukchi Sea 70°07'N 162°32'W	1	open water	about 50 m offshore from barrier islands
25 July 1984	1930-2100	Chukchi Sea 69°28.9'N 163°35.7'W	8	open water	3 large males, 5 small to medium-sized animals
26 July 1984	1400	Chukchi Sea 68°54'N 166°12.9'W	6	open water	3 large males, 3 small to medium-sized animals

In mid-September 1983, we received a report of a Killer Whale beached near Shaktoolik, about 8 km south of the old village site. The whale, examined by Mr. Clarence Katchatag of Shaktoolik, was reported to be a male, 10 m long with a dorsal fin 1.4 m high. A tooth was obtained from which a minimum age of 14 years was determined. Unfortunately, we were not able to verify the reported length of the whale or the manner in which it was determined.

On 12 June 1984 the Alaska Department of Fish and Game office in Bethel was notified of a group of Killer Whales stranded on Nunivak Island. Some details of the stranding were made available to us by

residents of Mekoryuk, particularly Mr. Jack Williams. The stranding occurred near the north end of the island on a gently sloping sand beach bordered by rocky points. The whales were first found on the beach in early to mid-May after the sea ice had moved away from shore. At that time, four small animals, arranged parallel to one another pointing shoreward, were all alive. A larger animal lay dead slightly to the seaward of the others, parallel to the beach and perpendicular to the other four whales. Later in the month, the small animals were also dead. According to residents, it is not unusual to see Killer Whales near Nunivak; however, the stranding was a very rare occurrence.

Predation on marine mammals

At approximately 1400 h on 5 August 1975 RRN saw a pod of seven Killer Whales chasing a Minke Whale (*Balaenoptera acutorostrata*) in the waters bordering the west side of Amaknak Island, near Dutch Harbor (Figure 1). The Minke Whale was traveling rapidly along the beach in a southerly direction inshore of the kelp beds. The Killer Whales were rapidly swimming in the same direction, parallel to the beach on the outside of the kelp. The Minke Whale ran aground on one of the numerous shoals that extend seaward from the beach where the incident took place. At this time, a large male Killer Whale swam shoreward through the kelp bed and approached to within approximately 10 m of the stranded Minke before turning around and heading back into deeper water. After about five minutes the Minke Whale dislodged itself and moved briefly into deeper water. It then swam forcefully onto the adjacent gravel beach and lay rather passively in approximately 0.5 m of water. The Killer Whales circled offshore for approximately 15 minutes before leaving the area.

Attempts by local residents to direct the Minke back to sea were unsuccessful as the whale repeatedly beached itself. The whale was later examined and measured and found to be a 7.3 m long female, apparently in good physical condition. Although there were numerous superficial cuts in the skin which were probably caused by barnacles, there were no obvious marks on any portion of the Minke Whale's torso that could be attributed to Killer Whales. Blubber was 5 cm thick and the stomach contained approximately 100 liters of mostly digested walleye pollock (*Theragra chalcogramma*).

At 1930 h on 25 July 1984 in the northeastern Chukchi Sea (Figure 1) RRN and LFL saw a group of eight Killer Whales at a distance of about 3 km. As the ship approached, we saw numerous rolls and blows of Killer Whales as well as occasional low spouts not accompanied by a back or fin. As we neared the center of activity at approximately 1940 h, we could see a slick on the water and the dorsal surface of a dead Gray Whale (*Eschrichtius robustus*) amid the group of Killer Whales. This group consisted of three large males and five small to medium-sized animals. For the following 60 minutes we watched as the Killer Whales fed on the Gray Whale carcass. The Killer Whales were spread out over an area about 1 km in diameter. One to three whales at a time approached the carcass at high speed, grasped it in their mouths, and attempted to tear off pieces of hide and blubber. Approximately 12 such "attacks" were seen. On four instances one or two whales grasped the carcass and took it below the surface for 40 to 120 seconds. Once,

the Gray Whale reappeared tail first, the flukes rising 2-3 m above the surface as if it were being pushed from below. During the period of our observations, most of the feeding was done by the small and medium-sized animals.

We later examined the Gray Whale, which was a female approximately 7 m long. There were numerous shallow lacerations and tooth marks on the flukes and peduncle, but the only obvious major damage was in the anterior region. All tissue was removed from the mandible and a large section of hide and blubber had been torn from the thorax, exposing some muscle and blood. The tongue and several small sections of hide and blubber from the maxillary region were missing. The blubber in the ventral region was 10 cm thick. The stomach contained a small quantity of recently eaten benthic crustaceans.

Our third observation is less direct. During the early afternoon of 20 August 1983, while on board the Soviet Research Vessel *Zykovo*, RRN sighted two male Killer Whales in the vicinity of Bering Strait. Shortly afterwards, less than three miles to the south, we encountered a dead Gray Whale and a dead Walrus (*Odobenus rosmarus*) floating about 300 m apart. Blood and oil were evident in the water surrounding the Gray Whale carcass. It was not possible to examine the carcass closely, although some lacerations and probable tooth marks were visible. The Walrus carcass was intact and no tooth marks were seen on it, but large contusions were evident.

Discussion

The observations reported here, in combination with other anecdotal information and the published literature, confirm that Killer Whales are not uncommon in the eastern Bering and Chukchi seas. Previous reports (e.g. Braham and Dahlheim 1982; Leatherwood et al. 1983b) indicate the species is widely distributed in the southern Bering Sea with a notable concentration in the eastern Aleutians-Unimak Pass area (Murie 1959). Previous sightings have been principally in open water. Our observations confirm the presence of Killer Whales in the seasonal ice front and ice remnants, as well, during March-May. Such ice habitats support large numbers of ice-associated seals (Phocidae) and Pacific Walruses, *Odobenus rosmarus* (Burns 1970).

Killer Whales do not appear to be common in inner Bristol Bay. During late spring and summer this is an area of great activity associated with intensive fisheries for herring (*Clupea harengus*) and salmon (*Oncorhynchus* spp.), and at least during these times of year, it is much more thoroughly covered by capable observers than areas farther north. We saw no

Killer Whales in the area during two summers of researching the distribution and movements of Beluga Whales (*Delphinapterus leucas*) which are abundant there (see Frost et al. 1984). None were seen on any of 12 extensive aerial surveys for marine mammals we conducted in Bristol Bay from April 1980 to May 1981. Likewise, the data bases summarized by Braham and Dahlheim (1982) and Leatherwood et al. (1983b) included few sightings in Bristol Bay and those were mostly in the southwestern portion.

In the northern Bering Sea Killer Whales are sometimes seen by people on St. Lawrence Island, King Island, and Little Diomed Island (Frost et al. 1983a; Don Ljungblad, personal communication). In the eastern Chukchi Sea they are regularly seen along the coast during summer by residents of Shishmaref, Point Hope, and Wainwright and have also been sighted in Kotzebue Sound and near Point Lay and Barrow (Frost et al. 1983b). Ivashin and Votrogov (1981) have summarized recent Soviet records from the northern Bering and Chukchi seas. They consider Killer Whales widely distributed but "relatively scarce" in coastal waters. In the western Beaufort Sea two sightings of Killer Whales were made near the ice margin in September 1974, and a single animal was seen in loose ice at 72°28.5'N 156°06.7'W on 17 September 1982 (John J. Burns, personal communication). The latter is the most northerly sighting of which we are aware. The only apparent record of Killer Whales in the central or eastern Beaufort Sea is of two animals sighted in Liverpool Bay on 2 August 1962 (David Patriguin, personal communication).

Local residents considered the three recent strandings of Killer Whales in the eastern Bering Sea very unusual. The appearance on shore of 10 animals in a three-year period is unusual in our experience as well. We know of only four other records of Killer Whales stranded on the coast of western Alaska. The carcass of an 8.3 m long whale washed ashore on a beach near Nome in 1936 (Stephen Leatherwood, personal communication). Murie (1959) found a carcass on Agattu Island but reported no other details. A Killer Whale carcass was seen on the north side of the Seward Peninsula on 29 July 1980 (Dan Stewart, personal communication). The fourth record was of a large Killer Whale stranded on a sand bar in central Kvichak Bay in summer 1982 (Roy DeHart, personal communication). The whale was seen alive at low tide and was not observed again, so we do not know whether or not it survived. In the Cook Inlet region only two Killer Whale strandings were recorded during the period 1940-1979 (Francis H. Fay unpublished).

Killer Whale strandings have also been recorded in

other areas. Strandings appear to be relatively uncommon in the North Atlantic (Brown 1975; Sergeant 1979) and the temperate and tropical eastern Pacific (Dahlheim et al. 1982) but are more frequent near New Zealand (Sergeant 1982).

We have no information on the causes of recent strandings in the Bering Sea, and since our informants were native hunters who are excellent observers of their natural surroundings, we assume that the animals were not obviously wounded or injured. Heavy ice drifting into a bay was the cause of a stranding in Newfoundland in 1957 (Dearden 1958) and may have been a factor at Nunivak since the whales were discovered shortly after sea ice had left the area. The nature of the relationship between the abundance of a species and the rate of stranding is unclear (Brown 1975; Sergeant 1979). Nevertheless, our records suggest that the abundance or rate of occurrence of Killer Whales in the Nunivak Island-Norton Sound region may have increased in recent years.

Although we could not verify that Killer Whales had actually killed the animal they were with when we located them, there can be little doubt that in the Bering and Chukchi seas Killer Whales sometimes prey on other marine mammals. Gray Whales, in particular, are very abundant in the region in late spring and summer and are killed and eaten (Tomilin 1957). Instances of Killer Whales chasing and attacking Gray Whales have been reported to us by residents of Little Diomed, Point Hope, and Wainwright. Our observation in the Chukchi Sea corresponded closely to a similar event off the coast of California (Baldrige 1972), and in many ways appeared to be the conclusion of a chase sequence witnessed by Ljungblad and Moore (1983) in the northern Bering Sea in May 1981. Minke Whales are also attacked and eaten. Researchers witnessed the killing of a Minke Whale by a group of six Killer Whales in the northern Gulf of Alaska on 29 April 1976 (Anonymous 1978). Our observations of the incident near Dutch Harbor and those of Hancock (1965) suggest that Killer Whales may sometimes take advantage of coastal features such as small bays when hunting fast-swimming species such as Minke Whales.

Walrus, both adults and calves, are sometimes killed by Killer Whales (Tomilin 1957; Fay 1982). Eskimos from King Island and Little Diomed Island have reported to us that Killer Whales are often seen "harassing" groups of Walrus during summer. Although there is no doubt that Killer Whales sometimes eat Walrus (Tomilin 1957), all the carcasses of Walrus that have been examined and diagnosed as killed by Killer Whales have been virtually intact (Fay 1982; Lloyd F. Lowry

unpublished). Don Ljungblad (personal communication) saw a Killer Whale near St. Lawrence Island run into a Walrus at high speed. A large amount of blood immediately appeared in the water but the Killer Whale did not change course or slow down. Killer Whales have access to Walruses both in the pack ice of the Bering and Chukchi seas, and near coastal haulouts in Alaska and Siberia.

We know of only one record of beach-cast remains of a Beluga killed by Killer Whales. An Eskimo hunter from St. Lawrence Island found an adult Beluga on 7 November 1967 which he said had been killed by a Killer Whale (Francis H. Fay, personal communication). Tomilin (1957) describes one observation in which Belugas were "torn to pieces" by a group of Killer Whales and a similar encounter was described in Kleinenberg et al. (1964). On 15 July 1979, a single Killer Whale chased a group of Belugas and killed a calf about 100 m offshore near the village of Point Lay (Glenn Seaman, personal communication). John J. Burns (personal communication) has received several reports from residents of Kotzebue Sound who have seen Killer Whales chasing, and on occasion, capturing Belugas.

There are few records of predation by Killer Whales on seals in the Bering and Chukchi seas. Tomilin (1957) reported that 60 claws from Bearded Seals (*Erignathus barbatus*) were found in the stomachs of two Killer Whales taken in the Gulf of Anadyr, and seal whiskers were found in the stomach of the whale that washed ashore near Nome in 1936 (Stephen Leatherwood, personal communication). Bearded Seals and other species such as Ringed (*Phoca hispida*), Ribbon (*P. fasciata*), and Spotted (*P. largha*) seals are seasonally abundant in the area and may be included in the diet of Killer Whales.

Conclusions

Our observations confirm that Killer Whales occur all along the coast of western Alaska from at least Bristol Bay to north of Point Barrow. Available data are not adequate to determine the number of individuals or pods utilizing the area. These animals appear to range widely and those which summer north of Bering Strait undoubtedly move long distances in order to winter south of the heavy ice pack which covers the northern Bering Sea. They do not, however, avoid ice entirely and may be relatively common in the ice fringe and front during spring.

Three strandings, involving 10 animals, occurred in the area between Norton Sound and Nunivak Island from 1982 to 1984. These occurrences were unusual, and the causative factors are unknown.

Other marine mammals form a portion of the diet of Killer Whales in the Bering and Chukchi seas.

Documented marine mammal prey species are Gray Whales, Minke Whales, Walruses, Beluga Whales, and seals.

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Literature Cited

- Anonymous.** 1978. Alaska whales and whaling. Alaska Geographic Volume 5, Number 4.
- Baldrige, A.** 1972. Killer whales attack and eat a gray whale. *Journal of Mammalogy* 53: 898-900.
- Braham, H. W., and M. E. Dahlheim.** 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Report of the International Whaling Commission 32: 643-646.
- Brown, S. G.** 1975. Relation between stranding mortality and population abundance of smaller Cetacea in the northeast Atlantic Ocean. *Journal of the Fisheries Research Board of Canada* 32: 1095-1099.
- Burns, J. J.** 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi seas. *Journal of Mammalogy* 51: 445-454.
- Dahlheim, M. E.** 1981. A review of the biology and exploitation of the killer whale, *Orcinus orca*, with comments on recent sightings from Antarctica. Report of the International Whaling Commission 31: 541-546.
- Dahlheim, M. E., S. Leatherwood, and W. F. Perrin.** 1982. Distribution of killer whales in the warm temperate and tropical eastern Pacific. Report of the International Whaling Commission 32: 647-653.
- Dearden, J. C.** 1958. A stranding of Killer Whales in Newfoundland. *Canadian Field-Naturalist* 72: 166-167.
- Fay, F. H.** 1982. Ecology and biology of the Pacific walrus, *Odobenus rosmarus divergens* Illiger. U.S. Fish and Wildlife Service, North American Fauna 74: 1-279.
- Frost, K. J., L. F. Lowry, and J. J. Burns.** 1983a. Distribution of marine mammals in the coastal zone of the Bering Sea during summer and autumn. Pp. 365-561 in *Environmental assessment of the Alaskan Continental Shelf, final reports of principal investigators, Volume 20. Outer Continental Shelf Environmental Assessment Program, Juneau, Alaska.*
- Frost, K. J., L. F. Lowry, and J. J. Burns.** 1983b.

- Distribution of marine mammals in the coastal zone of the eastern Chukchi Sea during summer and autumn. Pp. 563-650 in *Environmental assessment of the Alaskan Continental Shelf*, final reports of principal investigators, Volume 20. Outer Continental Shelf Environmental Assessment Program, Juneau, Alaska.
- Frost, K. J., L. F. Lowry, and R. R. Nelson.** 1984. Beluga whale studies in Bristol Bay, Alaska. Pp. 187-200 in *Proceedings of the workshop on biological interactions among marine mammals and commercial fisheries in the southeastern Bering Sea*, October 18-21, 1983, Anchorage, Alaska. Alaska Sea Grant Report 84-1.
- Hancock, D.** 1965. Killer whales kill and eat a minke whale. *Journal of Mammalogy* 46: 341-342.
- Ivashin, M. V., and L. M. Votrogov.** 1981. Killer whales, *Orcinus orca*, inhabiting inshore waters of the Chukotka coast. Report of the International Whaling Commission 31: 521.
- Kleinenberg, S. E., A. V. Yablokov, B. M. Belkovich, and M. N. Tarasevich.** 1964. Beluga (*Delphinapterus leucas*): Investigation of the species. Translated from Russian by Israel Program for Scientific Translations (IPST Cat. No. 1923).
- Leatherwood, S., E. Krygier, J. D. Hall, S. Ignell, and A. E. Bowles.** 1983a. Killer whales (*Orcinus orca*) in Southeast Alaska, Prince William Sound, and Shelikof Strait; a review of available information. International Whaling Commission Report. SC/35/SM 7.
- Leatherwood, S., A. E. Bowles, and R. R. Reeves.** 1983b. Endangered whales of the eastern Bering Sea and Shelikof Strait, Alaska. Hubbs-Sea World Research Institute Technical Report No. 83-159.
- Ljungblad, D. K., and S. E. Moore.** 1983. Killer whales (*Orcinus orca*) chasing gray whales (*Eschrichtius robustus*) in the northern Bering Sea. *Arctic* 36: 361-364.
- Murie, O. J.** 1959. Fauna of the Aleutian Islands and Alaska Peninsula. U.S. Fish and Wildlife Service, North American Fauna 61: 1-364.
- Sergeant, D. E.** 1979. Ecological aspects of cetacean strandings. Pp. 94-113 in *Biology of marine mammals: insights through strandings. Final Report. Edited by J. R. Geraci and D. J. St. Aubin.* MMC-77/13. U.S. Marine Mammal Commission, Washington, D.C.
- Sergeant, D. E.** 1982. Mass strandings of toothed whales (Odontoceti) as a population phenomenon. *Scientific Reports of the Whales Research Institute* 34: 1-47.
- Tomilin, A. G.** 1957. Cetacea. In *Mammals of the U.S.S.R. and adjacent countries. Edited by V. G. Heptner.* Translated from Russian by Israel Program for Scientific Translations (IPST Cat. No. 1224).

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Changes in Daily Activity Rhythms of Some Free-ranging Animals in Minnesota

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Activity patterns of many vertebrates have been monitored by an automatic radio tracking system at the Cedar Creek Natural History Area in east-central Minnesota. Activity rhythms of Gray Squirrels (*Sciurus carolinensis*), Red Foxes (*Vulpes vulpes*), Muskrats (*Ondatra zibethicus*), Ruffed Grouse (*Bonasa umbellus*) and Barred Owls (*Strix varia*) show marked seasonal changes which are believed to be responses to environmental conditions or physiological and behavioral requirements of the animal. Variations in number of activity periods, total minutes of activity, timing of activity in relation to sunrise and sunset, and in the amount of rest during the normal active period are shown to be related to changes in such factors as temperature, snow cover, food supply and breeding behavior. These modifications of activity rhythms suggest that controlling mechanisms are sufficiently plastic to allow animals to alter their behavior significantly in response to a changing environment. In contrast, animals in captivity show remarkably precise timing with respect to activity rhythms. This regularity appears to be highly dependent on caging and the uniformity of environmental conditions under which such animals are maintained.

Key Words: Activity rhythms, Gray Squirrel, *Sciurus carolinensis*, Red Fox, *Vulpes vulpes*, Muskrat, *Ondatra zibethicus*, Ruffed Grouse, *Bonasa umbellus*, Barred Owl, *Strix varia*, Minnesota.

The daily activity pattern of any free-ranging animal is determined by an endogenous mechanism whose output is modified by both biological and environmental factors, which themselves exhibit seasonal changes. However, the adaptive significance of such changes is not well understood (Daan 1981; Rusak 1981). Data on the activity patterns of wild animals living under natural conditions have often been anecdotal, whereas detailed information has been obtained for many species in captivity. Analyses of these latter data have indicated remarkably precise patterns of activity from day to day for individual species. Experimental studies have revealed an endogenous mechanism of timing which persists in the absence of environmental stimuli.

Development of automatic telemetry techniques for monitoring the activity of wild animals has made it possible to obtain long-term data on rhythms of many species of vertebrates living under natural conditions. This paper uses available data to show that activity rhythms of wild animals living under natural conditions do not exhibit high precision nor do they maintain the same pattern throughout the year, in spite of an endogenous mechanism and an environmental Zeitgeber. Possible explanations for these changes are considered in terms of the abilities of the various species to survive and reproduce. Examples have been chosen from both birds and mammals studied at the Cedar Creek Natural History Area in east-central Minnesota.

Enright (1970) suggested that laboratory studies of

endogenous rhythms might have little relevance to ecology. On the other hand, data on activity rhythms of captive animals and of wild animals are often cited together in papers dealing with endogenous rhythms (Daan and Aschoff 1975). Uniformity or consistency of the observed rhythms is often implied. Data in this paper reveal striking seasonal changes and great plasticity in daily activity rhythms of a variety of birds and mammals, suggesting that uniformity or consistency of rhythms is rare in nature. Students of endogenous rhythms in the laboratory, whether or not they are expecting to contribute to ecological understanding, should be well aware of the potential influence of environment on wheel-running, feeding or other measures of activity.

Methods

Study animals were captured in live traps, in drive nets and by a variety of other methods (Keith et al. 1968; Huempfer et al. 1975). Each animal was fitted with a radio transmitter broadcasting on a unique frequency in the 53 MHz range (Tester et al. 1964). The transmitters were designed either with the broadcasting antenna forming a collar, or as a back and breast harness with a whip antenna extending along the back. Transmitters weighed 35 to 42 grams, had an expected life of 180 days, and an effective range of about 1.6 km.

Radio signals from the individual animals were monitored by the Cedar Creek automatic radio tracking system (Cochran et al. 1965; Tester 1978).

Location and activity were determined for each animal from data recorded on microfilm every 45 seconds. Field observations of radio-marked animals confirmed that the recorded data corresponded to activity and rest (Tester 1971).

The radio signal from a motionless animal appeared as a continuous black bar on the microfilm records, whereas signals from a moving animal appeared as broken or interrupted bars. These breaks were caused by modulation of the radio signal due to a change in capacitance of the circuit as the collar changed position on the neck of the animal or as the whip antenna moved or vibrated. The characteristics of the radio signal on the microfilm record provided a means of determining, to the nearest minute, when an animal was active or resting. Specific types of activity, such as running, feeding, or grooming could not be differentiated from the radio signals. However, modifications of selected receivers in the automatic tracking system enabled drumming of male Ruffed Grouse to be monitored. In the analysis, data were summarized for 5 to 15 minute intervals, depending on the quality of data available and length of the study period for each species.

Data from the microfilm records were recorded manually on tabulation sheets and encoded on computer punch cards for further analysis on a Control Data Cyber 74 system. The analysis program was designed to show each daily pattern of rest and activity for an individual animal and to summarize rest and activity over specified time periods, such as weekly or monthly.

Weather data were recorded at the U.S. Weather Bureau Station at the Cedar Creek Natural History Area. Sunrise and sunset times were determined from U.S. Naval Observatory Chart 1155 for Minneapolis. Breeding chronologies, types of behavior, and availability of food, such as acorns, were determined by direct field observations.

Results

GRAY SQUIRREL, *Sciurus carolinensis*

Gray Squirrels were monitored over a 15-month period from July 1971 through September 1972 (Bland 1977). Periods of activity and rest were plotted daily for each squirrel. Combining the data for all squirrels for each two week interval produced a series of graphs showing seasonal changes in activity patterns (Figure 1). Because data were obtained on a different number of squirrels during each two-week period, the individual graphs do not always represent identical numbers of animals. Although variations due to differences among squirrels and among days are not accounted for, these graphs provide a generalized picture of the activity waveform

throughout the year. Figure 1 shows clearly that a bimodal waveform is characteristic of early spring and summer. During winter, low intensity activity is expressed only during a narrow mid-day window. A square waveform denoting intense continuous activity extending for the entire daylight period is characteristic of fall and late spring. Thompson (1977) also observed a single mid-day peak in winter, and a bimodal pattern showing the seasonal maximum in summer, based on visual field data.

Although Figure 1 shows the general pattern of onset and end of activity with respect to sunrise and sunset, the cumulative nature of the graphs obscures much detail. Because activity onset and end represent critical times frequently used in analysis of circadian rhythms, figures were prepared to illustrate exact onset and cessation time of each animal. Figure 2 presents an example of such data for a juvenile female from 4 August 1971 to 10 September 1972. Though irregularity in onset and cessation times from day to day is apparent, one can also see a general pattern that changes with the season.

Activity onset and cessation times averaged for all squirrels were used to illustrate phase relationships with sunrise and sunset (Figure 3). A marked reduction in the $\alpha:p$ ratio in winter is apparent.

RED FOX, *Vulpes vulpes*

Red Foxes are primarily nocturnal, with activity onset occurring near sunset and activity end near sunrise, but with considerable daily, seasonal and individual variation (Ables 1969; Storm 1965; Tembrock 1958). Individuals monitored at Cedar Creek usually exhibited several periods of movement and rest daily. The typical 24-hour activity waveform was a sequence of relatively long periods of rest during the day followed by relatively long periods of movement at night. Major functions carried out during the active period included foraging and maintaining the territory occupied by the family (A. Sargeant, in preparation). In addition, activities associated with breeding occurred during late winter and spring. Feeding occurred at any time during the active period and did not always appear to be the most important behavioral function. In his analysis of behavior, A. Sargeant (in preparation) indicated that the distance traveled and rate of movement associated with foraging and territory maintenance remained relatively constant from day to day throughout the year. During summer, when nights are short, the intensity of activity was high throughout the period of darkness (Figure 4A). In contrast, during long winter nights when foxes had more time to carry out the required activities, they spent considerable time resting, as shown by the lower intensity of activity (Figure 4B).

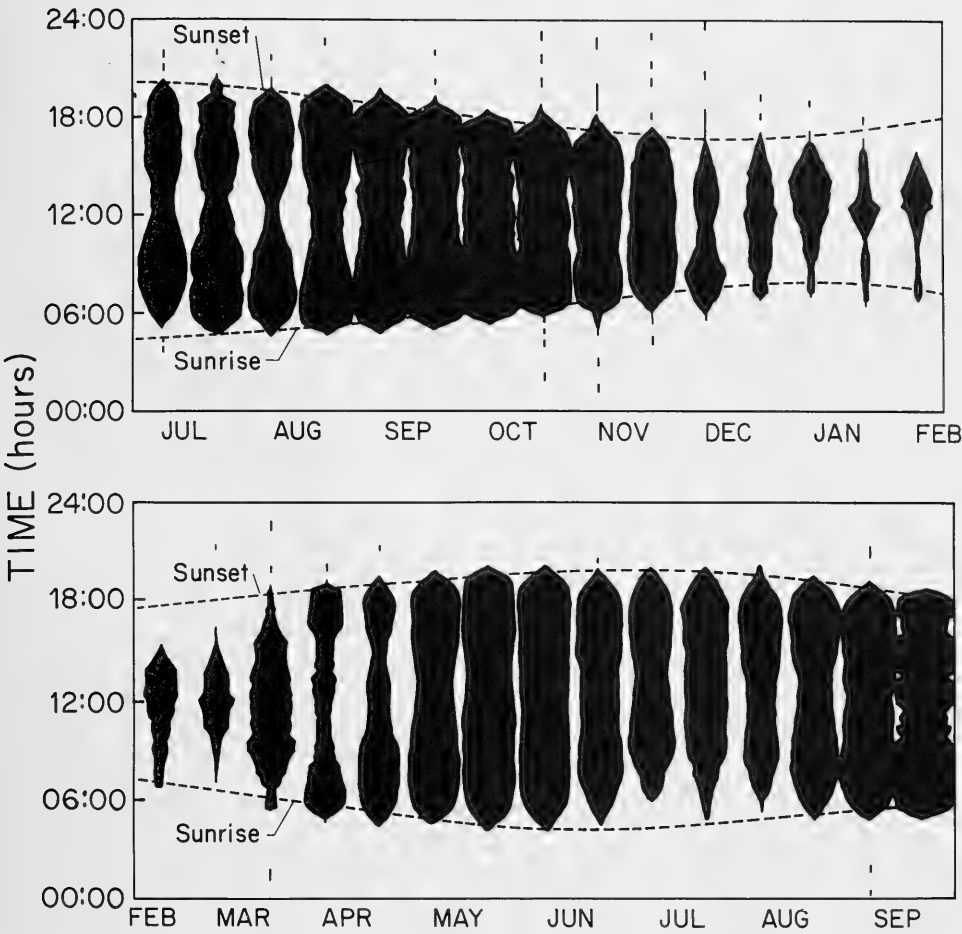


FIGURE 1. Seasonal activity patterns for Gray Squirrels from July 1971 to September 1972 (average for 4-8 squirrels). Full width of each period indicates 100% activity. The curved horizontal lines show sunrise and sunset. Time is Central Standard Time.

MUSKRAT, *Ondatra zibethicus*

In general, Muskrats are considered to be nocturnal. However, O'Neil (1949) and Errington (1963) suggested that high population density and/or certain meteorological conditions might result in increased diurnal activity. Van Horn (1975) reported an increase in diurnal activity after ice formed on his study lake in Wisconsin. Using data from tracks in sand transects, Stewart and Bider (1977) reported that Muskrats had a bimodal waveform with peaks occurring about 1630 h and 2230 h.

Muskrats at Cedar Creek exhibited an activity

rhythm quite different from that of Gray Squirrels and Red Foxes. During the period of study, from July 1969 through February 1970, the number of activity periods per 24 hours varied from two to four. From July through about 30 August, four periods of activity were about evenly distributed throughout the 24 hours. In subsequent months the number of activity periods was reduced to three and then to two. In this reduction, which occurred at the time of freeze-up of lakes and streams, the day activity periods were eliminated and Muskrats became essentially nocturnal (Figure 5). Unlike the Red Fox, the total

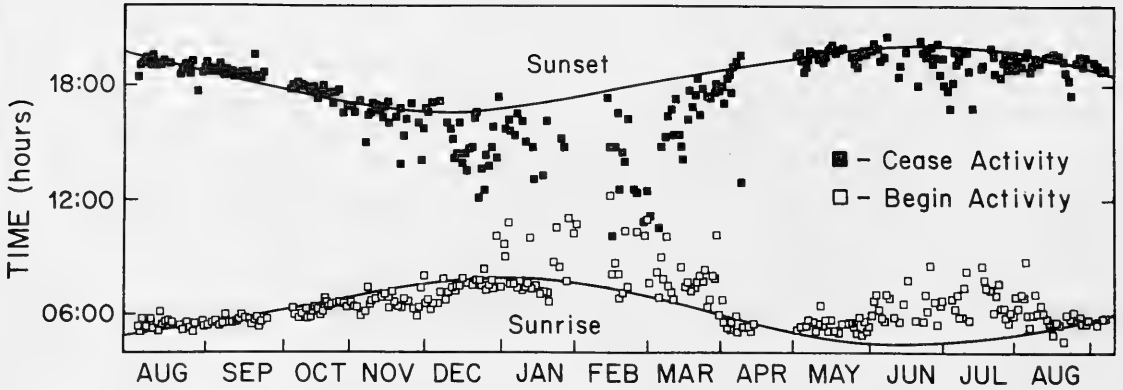


FIGURE 2. Onset and cessation of activity of a female Gray Squirrel from 4 August 1971 until 10 September 1972. Open squares represent onset, black squares represent cessation, and the curved lines show times of sunrise and sunset.

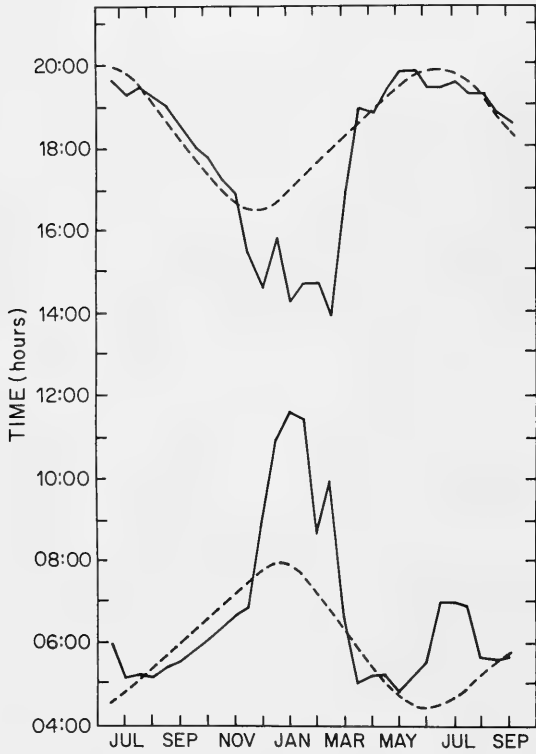


FIGURE 3. Phase relationships between onset and end of activity and sunrise and sunset for Gray Squirrels from July 1971 through September 1972. The solid lines represent activity onset and cessation and the dashed lines represent times of sunrise and sunset.

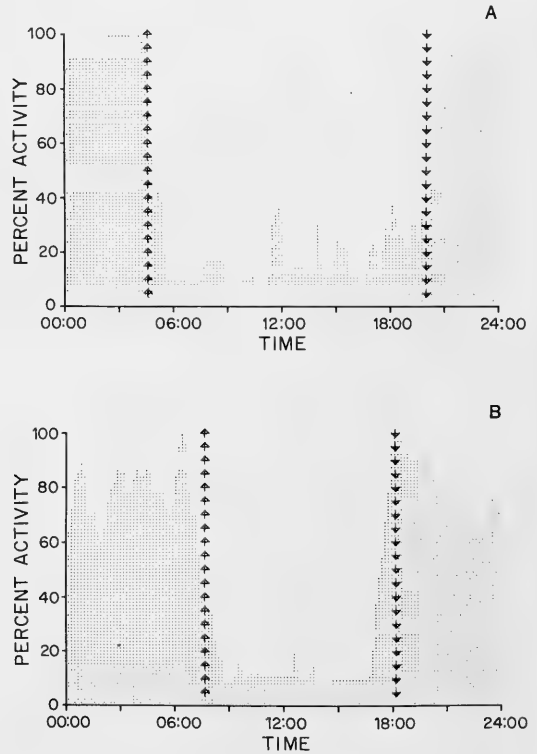


FIGURE 4. Activity patterns for an adult female Red Fox showing the percentage of days the fox was active for any given time during the 24 hours. Arrows show times of sunrise and sunset. A. Activity from 1 through 15 July 1964 illustrating pattern typical of short summer nights. B. Activity from 15 through 29 January 1964 illustrating pattern typical of long winter nights.

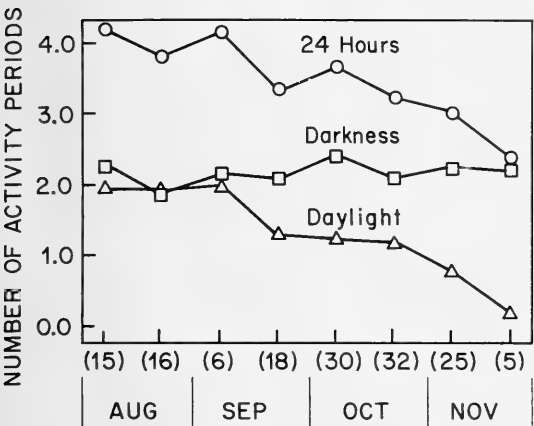


FIGURE 5. Mean number of activity periods for 24 hours, for daylight, and for darkness, for Muskrats from 1 August to 30 November 1969. Sample sizes in Muskrat-days are given in parenthesis.

minutes of activity per 24 hours was reduced to approximately half that exhibited in late summer.

While the reasons for this change are not known, it is probably related to the functions which Muskrats must carry out during this period of the year. In late summer and early fall Muskrats are building lodges and storing food in preparation for winter. These activities undoubtedly require that the animals be active for many minutes in each 24-hour period. After ice forms on the lakes and streams, Muskrats are no longer able to construct houses. For the duration of the ice-cover period they rely on stored food supplies and on foraging under the ice. Most activity during winter is probably related to feeding. One might expect this feeding to occur during the warmer temperatures of daytime; however, the temperature of the water under the ice where food is stored remains relatively constant at approximately 4°C until the spring thaw. The fact that the Muskrats were active at night during this period suggests that the species may be basically nocturnal but becomes active during the day when time is required for house building and food storage.

RUFFED GROUSE, *Bonasa umbellus*

Birds studied at Cedar Creek have also exhibited changes in activity rhythms in response to behavioral requirements or environmental stresses. Ruffed Grouse are normally diurnal and both sexes show a bimodal waveform with activity peaks near sunrise and sunset, similar to many other birds (Aschoff 1967). The examples presented below to illustrate plasticity in activity rhythms of Ruffed Grouse are

related to breeding and brood rearing behavior. During spring, male grouse display by drumming, which begins in early April and extends into July. Drumming may occur during either night or day, with the pattern changing as the season progresses. Activity associated with feeding and other daily functions, such as preening and territorial defense, are also carried out during the drumming season. Figure 6A illustrates activity of a male grouse for a two-week period during the peak of the drumming season. Archibald (1976) showed that drumming occurred throughout the day except for brief periods near sunrise and sunset when feeding activity was most pronounced. It is apparent from Figure 6A that this grouse was active nearly 100% of the daylight period. Although this high level of activity must place stress on the physiology of the males, such levels occur for

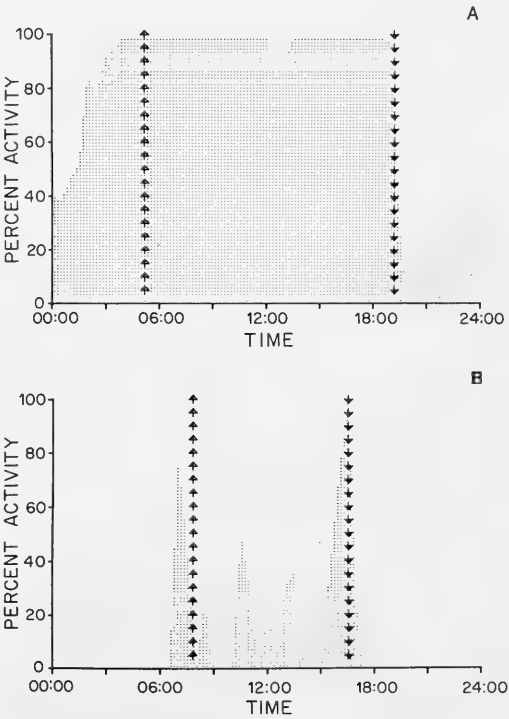


FIGURE 6. Activity pattern for adult male Ruffed Grouse showing percentage of days the grouse was active for any given time during the 24 hours. Arrows show times of sunrise and sunset. A. Activity from 23 to 29 April 1970 illustrating the high level of activity throughout nearly the entire 24 hours. B. Activity from 20 to 27 December 1971 illustrating the typical winter pattern of reduced activity with peaks occurring around sunrise and sunset.

only a few weeks during the year (Archibald 1976).

Activity in winter is markedly reduced, with obvious peaks near sunrise and sunset (Figure 6B). At this season activity is related mainly to feeding on buds and catkins of trees and shrubs (Huempfer and Tester, *in press*). Between feeding periods, grouse rest in depressions in the snow or burrow into soft, fluffy snow.

A somewhat similar type of short-term change in activity rhythm was discovered in female Ruffed Grouse (Maxson 1977). Prior to egg laying, hens exhibited the typical bimodal waveform, with activity beginning prior to sunrise and ending after sunset (Figure 7A). During incubation hens were on the nest for nearly the entire 24-hour period, with only brief periods of activity for feeding in early morning and late afternoon (Maxson 1977). Immediately after hatching, the hens altered their activity rhythm, beginning activity as much as several hours later in the morning and ending activity earlier in the evening (Figure 7B). In addition, the level of activity was higher throughout the active period compared with the pre-incubation period. Maxson (1977) believed that this delay of onset and early cessation was related to brooding behavior by the hen. Brooding during the cool, wet morning and evening hours reduced the exposure of chicks to chilling and wetting from heavy dew, thus helping them to maintain their body temperature. As the chicks grew older, activity patterns of the brood hens began to resemble those of the broodless hens.

BARRED OWLS, *Strix varia*

Phase relationships of activity onset and end with respect to sunset and sunrise were highly variable in Barred Owls studied by Fuller (1979). Positive and negative phase differences as great as 60 minutes were observed in a non-breeding female monitored for approximately six months. Non-breeding Barred Owls exhibited nocturnal activity patterns with peaks of activity usually occurring just after sunset and before sunrise; however, some activity was also detected at various times throughout the day.

Activity waveforms of breeding birds changed markedly through the breeding season (Figure 8). During incubation the female was active less than 3 percent of the time. The male, however, increased his activity at this time, presumably to obtain food for the incubating female. Fuller (1979) believed the marked increase in activity of both the male and female following hatching to be the result of increased hunting.

The time of year when the adults are feeding young corresponds to the time of year with short nights. Fuller observed that the adult Barred Owls were

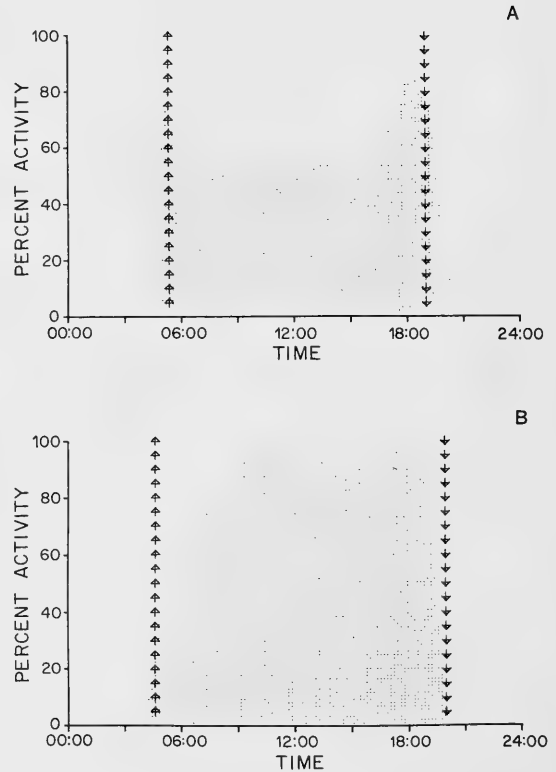


FIGURE 7. Activity patterns for an adult female Ruffed Grouse showing the percentage of days the grouse was active for any given time during the 24 hours. Arrows show times of sunrise and sunset. A. Activity during pre-incubation period illustrating the typical bimodal activity rhythm with onset prior to sunrise and cessation after sunset. B. Activity pattern during post-incubation illustrating the reduction in crepuscular activity associated with brooding.

forced to hunt during the day to provide adequate food for their young. However, he also observed non-breeding adult females hunting in daylight during this same time of the year. Similar behavior has also been observed for other owl species (Bunn 1972; Marti 1974).

Discussion

Comparison of these results with published accounts of activity rhythms of many species in captivity revealed that the animals living in the wild showed much variation in the times when activity began and ended in terms of the phase relationship to sunrise and sunset. In contrast, animals held in captivity showed remarkably precise timing from day

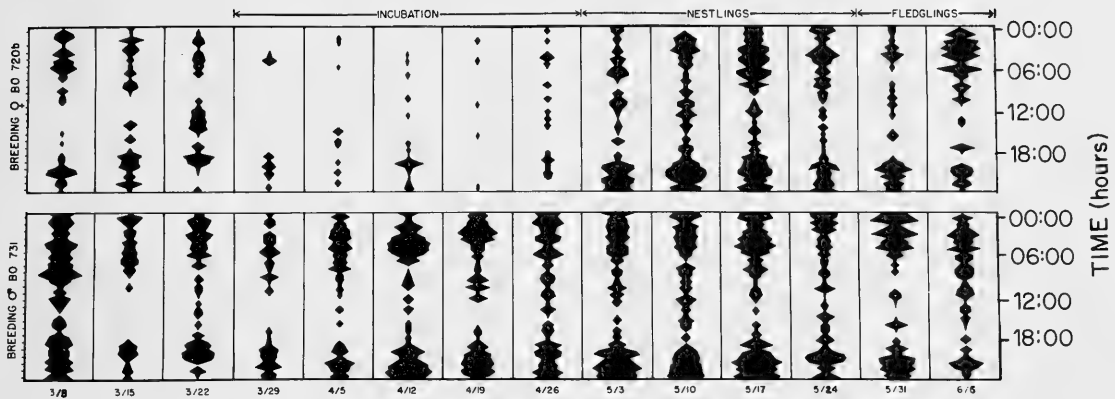


FIGURE 8. Activity patterns of a pair of Barred Owls during part of the breeding cycle in 1973 illustrating decreased activity by the female during incubation and an increase in daytime activity by the male after the young hatched. Full width of each period indicates 100% activity.

to day with respect to the onset and termination of activity as related to the light/dark regimen (Pittendrigh and Daan 1976). In addition, wild animals exhibited marked flexibility in the number of activity periods and total minutes of activity per 24 hours, and showed the ability to shift from night-active to day-active patterns when the need arose.

Much of the theory of seasonality of circadian rhythms assumes that length of twilight and length of day and night are the most important controlling factors (Aschoff 1969; Kenagy 1976; Wever 1967). The data from Cedar Creek, however, indicate that other factors override length of day and/or twilight. Using the data from Gray Squirrels as an illustration, one can see that the phase relationships between activity onset and sunrise (ψ onset) and activity end and sunset (ψ end) both show two maxima and two minima per year (Figure 3). The annual range of change in ψ onset was 294 minutes and in ψ end, 250 minutes. Such large amplitudes have not been reported in the literature, nor has the observed pattern been predicted by theory. It seems likely that ecological and ethological aspects of the biology of the squirrels and changes in environmental factors "damp out" the endogenous control of activity patterns and make data collected from free-ranging squirrels unsuitable for modeling the circadian system.

Data on activity patterns obtained from numerous species at Cedar Creek suggest that the endogenous timing mechanism is modified or overridden by other factors at various times throughout the year. A simple model (Figure 9) illustrates how environmental factors and biological factors may act to modify

activity patterns within the framework established by the Zeitgeber and the endogenous mechanism. Linkage of environmental and biological factors,

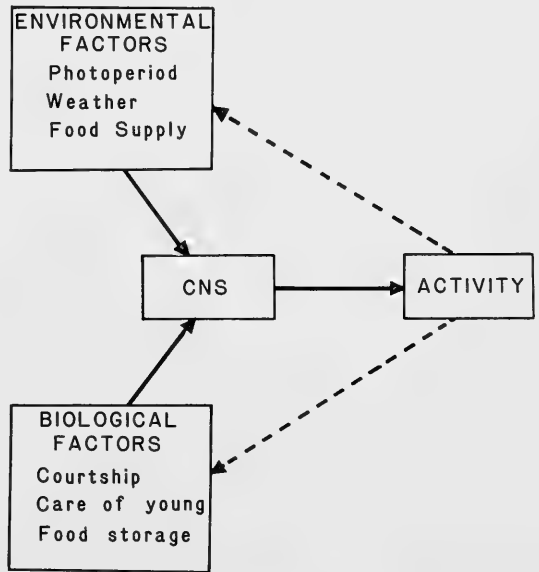


FIGURE 9. Model illustrating the influence of environmental and biological factors on activity rhythms of free-ranging animals. Feedback is shown by dashed lines leading from activity. Examples of environmental and biological factors which act on the central nervous system (CNS) are given in the appropriate compartments.

shown by solid lines, is through the central nervous system "pathway" controlling activity. The combination of these driving forces, mediated and integrated through the central nervous system, determines the activity exhibited by the animal. This activity may result in changes in environmental and biological factors, as indicated by the dashed feedback loops in the model. For example, food supplies in the environment may be reduced by foraging, or courtship activities may cease following mating.

Environmental factors such as day length have been shown by numerous investigations (Aschoff et al. 1982; Erkinaro 1969; and others) to influence activity rhythms. Studies described above indicate strong effects of such factors as ambient temperature and snow cover (Bland 1977), food supply (Bland 1977; Fuller 1979), and breeding behavior (Archibald 1976; Maxson 1977) on activity of free-ranging animals. In addition, A. Sargeant (in preparation) found that Red Foxes at Cedar Creek switched from nocturnal feeding to diurnal feeding during a winter with very thick snow cover. With the snow thickness exceeding 100 cm, Gray Squirrels were forced to burrow to find food. As a result, the squirrels were highly vulnerable and foxes became day-active and captured squirrels at the snow-tunnel entrances. Garshelis (1983) reported that male Sea Otters (*Enhydra lutris*) in Prince William Sound, Alaska, switched from their normal diurnal pattern of feeding and territory defense to nocturnal feeding when they moved to areas of richer food supply. These switches occurred quickly and lasted until the males returned to their territories.

Ecological and ethological factors, such as courtship and care of young by Ruffed Grouse, care of young by Barred Owls, and house building by Muskrats, had marked influences on activity rhythms. Changes in activity patterns were not as rapid as in the case of male Sea Otters, but did occur within a few days.

Rapid changes in activity rhythms suggest that the causative mechanism is neural rather than biochemical. Therefore, the driving forces of environmental and biological factors are given equal weight in the model (Figure 9). However, their individual strengths, as indicated by the solid lines, are not considered as strong as the Zeitgeber.

Many of the environmental and behavioral factors are controlled in laboratory studies, i.e. environmental chambers maintain constant physical conditions and animals in individual cages do not breed, care for young or search for food. Therefore, these driving forces are eliminated and observed behavior is determined by the Zeitgeber through the endogenous mechanism.

The plasticity in activity pattern is a vital part of the

adaptive mechanism which enables wild animals to survive in a changing environment. However, the endogenous component must also be considered vital in triggering the animal to become physiologically ready for activity (Dean and Aschoff 1982). In contrast, it appears that the regularity of rhythms of captive animals reflects endogenous control under stable environmental conditions. Researchers must be aware of these fundamental differences in the design of experiments and interpretation of results.

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Literature Cited

- Ables, E. D. 1969. Activity studies of Red Foxes in southern Wisconsin. *Journal of Wildlife Management* 33: 145-153.
- Archibald, H. L. 1976. Spring drumming patterns of Ruffed Grouse. *Auk* 93: 808-829.
- Aschoff, J. 1967. Circadian rhythms in birds. *Proceedings of the International Ornithological Congress* 14: 81-105.
- Aschoff, J. 1969. Phasenlage der Tagesperiodik in Abhängigkeit von Jahreszeit und Breitengrad. *Oecologia* 3: 125-165.
- Aschoff, J., S. Daan, and K. I. Honma. 1982. Zeitgebers, entrainment, and masking: some unsettled questions. Pp. 13-24 in *Vertebrate circadian systems*. Edited by J. Aschoff, S. Daan, and G. A. Gross. Springer-Verlag, Berlin.
- Bland, M. E. 1977. Daily and seasonal activity patterns in the eastern Gray Squirrel. Ph.D. thesis, University of Minnesota. 221 pp.
- Bunn, D. S. 1972. Regular daylight hunting by Barn Owls. *British Birds* 65: 26-30.
- Cochran, W. W., D. W. Warner, J. R. Tester, and V. B. Kuechle. 1965. Automatic radio-tracking system for monitoring animal movements. *Bio-Science* 15: 98-100.
- Daan, S. 1981. Adaptive daily strategies in behavior. Pp. 275-298 in *Handbook of behavioral neurobiology*.

- Volume 4, Biological rhythms. *Edited by J. Aschoff*. Plenum Press, New York.
- Daan, S., and J. Aschoff.** 1982. Circadian contributions to survival. Pp. 305-321 in *Vertebrate circadian systems. Edited by J. Aschoff, S. Daan and G. A. Gross*. Springer-Verlag, Berlin.
- Daan, S., and J. Aschoff.** 1975. Circadian rhythms of locomotor activity in captive birds and mammals: their variations with season and latitude. *Oecologia* 18: 269-316.
- Enright, J. T.** 1970. Ecological aspects of endogenous rhythmicity. *Annual Review of Ecology and Systematics* 1: 221-238.
- Erkinaro, E.** 1969. Der Phasenwechsel der lokomotorischen Aktivität bei *Microtus agrestis*, *M. arvalis* and *M. oeconomus*. *Aquilo, series Zoologica* 8: 3-31.
- Errington, P. L.** 1963. Muskrat populations. Iowa State University Press, Ames. 665 pp.
- Fuller, M. R.** 1979. Spatiotemporal ecology of four sympatric raptor species. Ph.D. thesis, University of Minnesota, Minneapolis. 396 pp.
- Garshelis, D. L.** 1983. Ecology of Sea Otters in Prince William Sound, Alaska. Ph.D. thesis, University of Minnesota, Minneapolis. 321 pp.
- Huempfer, R. A., S. J. Maxson, G. J. Erickson, and R. J. Schuster.** 1975. Recapturing radio-tagged grouse by nightlighting and snow-burrow netting. *Journal of Wildlife Management* 39: 821-823.
- Huempfer, R. A., and J. R. Tester.** *In press*. Winter arboreal feeding behavior of Ruffed Grouse in east-central Minnesota. In *Adaptive strategies and population ecology of North America grouse. Edited by T. Bergerud*. University of Minnesota Press, Minneapolis.
- Keith, L. B., E. C. Meslow, and O. J. Rongstad.** 1968. Techniques for snowshoe hare population studies. *Journal of Wildlife Management* 32: 801-812.
- Kenagy, G. J.** 1976. The periodicity of daily activities and its seasonal changes in free-ranging and captive Kangaroo Rats. *Oecologia* 24: 105-140.
- Marti, C. D.** 1974. Feeding ecology of four sympatric owls. *Condor* 76: 45-61.
- Maxson, S. J.** 1977. Activity patterns of female Ruffed Grouse during the breeding season. *Wilson Bulletin* 89: 439-455.
- O'Neil, T.** 1949. The muskrat in the Louisiana coastal marshes. Louisiana Department of Wildlife and Fisheries, New Orleans. 152 pp.
- Pittendrigh, C. S., and S. Daan.** 1976. A functional analysis of circadian pacemakers in nocturnal rodents. I. The stability and lability of spontaneous frequency. *Journal of Comparative Physiology* 106: 223-252.
- Rusak, B.** 1981. Vertebrate behavioral rhythms. Pp. 275-298 in *Handbook of behavioral neurobiology. Volume 4, Biological rhythms. Edited by J. Aschoff*. Plenum Press, New York.
- Stewart, R. W., and J. R. Bider.** 1977. Summer activity of Muskrats in relation to weather. *Journal of Wildlife Management* 41: 487-499.
- Storm, G. L.** 1965. Movements and activities of foxes as determined by radio-tracking. *Journal of Wildlife Management* 29: 1-13.
- Tembrock, G.** 1958. Periods of activity in *Vulpes* and *Alopex*. *Zoologisches Jahrbuch Physiologie* 68: 297-324.
- Tester, J. R.** 1971. Interpretation of ecological and behavioral data on wild animals obtained by telemetry with special reference to errors and uncertainties. Pp. 383-408 in *Symposium on biotelemetry*, Pretoria, South Africa.
- Tester, J. R.** 1978. Analysis of circadian rhythms of free-ranging mammals. Pp. 167-170 in *Biotelemetry IV. Edited by H. J. Klewe and H. P. Kimmich*. Doring-Druck, Drukerei und Verlag, Braunschweig, West Germany.
- Tester, J. R., D. W. Warner, and W. W. Cochran.** 1964. A radio-tracking system for studying movements of deer. *Journal of Wildlife Management* 28: 42-45.
- Thompson, D. C.** 1977. Diurnal and seasonal activity of the Gray Squirrel (*Sciurus carolinensis*). *Canadian Journal of Zoology* 55: 1185-1189.
- Van Horn, S. D.** 1975. Activity and feeding rhythms in the Muskrat, (*Ondatra zibethicus*). Ph.D. thesis, University of Wisconsin, Madison. 101 pp.
- Wever, R.** 1967. Zum Einfluss der Dämmerung auf die circadiane Periodik. *Zeitschrift Vergleichende Physiologie* 55: 255-277.

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Snowmobiling Impact on Snow and Soil Properties and on Winter Cereal Crops

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This study was initiated in two different climatic zones of Quebec to investigate the effects of snowmobile traffic on snow and soil physical properties and on winter cereal crops. For two years test plots of wheat and rye were established late in summer at Lennoxville (45°22' N, 71°51' W) and La Pocatière (47°21' N, 70°02' W) and were subjected to snowmobile traffic from the beginning of December to the end of March. Once a week, snow depth, snow density, snow and soil temperature readings and soil moisture determinations were taken on treated and untreated areas. Snow density ($\text{g}\cdot\text{cc}^{-1}$) under the track was 1.7 times greater than the untreated snow and reached a maximum level after four runs, transmitting heat from the soil below at a rate of five times that of undisturbed snow. Snowmobiling has induced a significant alteration in the slopes of the gradient profiles for compacted snow. Under the track areas, soil temperature decreased sharply and frost penetration reached depths of as much as 60 cm. Compacted snow lingered several days longer due to the colder soil underneath and the increased snow density. Soil temperature under compacted and undisturbed snow did not equilibrate until the first week of May. The water content of frozen soil layers was two to three times higher than that of the unfrozen portion of the profile. Yields of winter wheat and rye exposed to snowmobile traffic were not significantly reduced below those of check areas.

Au cours de deux années, on a étudié l'effet de la motoneige sur les propriétés physiques de la neige et du sol et sur le rendement des céréales d'automne. Des parcelles de blé et de seigle ont été établies à Lennoxville (45°22' Nord, 71°51' ouest) et La Pocatière (47°21' Nord, 70°02' ouest) et soumises aux passages de la motoneige de décembre à mars. A toutes les semaines, on a mesuré l'épaisseur, la densité et la température au sein de la neige, la température et l'humidité du sol en-dehors et sur la piste de motoneige. La neige a été 1.7 fois plus dense sur la piste et a atteint une densité maximale après quatre passages. La conductivité thermique a été cinq fois plus élevée sur la piste et le gel a pénétré jusqu'à 60 cm de profondeur dans le sol. La neige tassée a pris beaucoup plus de temps à fondre à cause d'une densité plus élevée et de la persistance du gel dans le sol sous-jacent. Les températures du sol entre les deux traitements ne se sont équilibrées qu'au début de mai. La portion de sol gelée sous la piste contenait de deux à trois fois plus d'eau que la portion non gelée. Le rendement total du blé et du seigle n'a pas été affecté significativement par la motoneige.

Key Words: Snowmobiling, snow temperature, density and thickness, soil temperature and freezing, thaw, cereal crops, Québec.

Snowmobiling is a popular winter sport in northern countries. Concern has increased about the impact of this activity on the environment, especially among agricultural landowners who are worried about its effects on soil and on plant persistence. The snowmobile has been severely criticized by environmentalists but there is scant evidence to prove or disprove their contentions.

Tests conducted by Newmann and Merriam (1972) showed an increase in heat conduction in snow after passage of a snowmobile. Temperatures at the soil surface below heavily travelled trails were approximately 2.8°C lower than non-track areas (Pendleton and Walejko 1972). Snowmobile packing reduces the insulative quality of snow cover by decreasing depth and promotes increased density of snow (Schmid 1971). Wanek (1971a,b, 1972, 1973) noted that snowmobile traffic may alter the soil temperature regime by compacting natural snow and consequently could retard the decomposition of organic matter and formation of humus. He concluded that snowmobil-

ing has an impact on soil microbes and on vegetation. The reports of Walejko et al. (1973) and Foresman et al. (1976) showed that these off-road vehicles may cause reduced grass yields, the degree of reduction depending on location, number of runs, and on snow depth. Little is known of the total impact of snowmobiles on thermal erosion of compacted snow and of the soil.

The objective of this research was to determine the effects of snowmobile traffic on snow and soil properties and also to test if claims of snowmobile damage to winter cereals were well founded.

Materials and Methods

Studies were conducted on two test sites over a two-year period starting in fall 1973 at Lennoxville (site I) and La Pocatière (site II). The two locations were selected for their differences in snow conditions, soil types, and length of the snowmobiling season. One site was in the vicinity of the Lennoxville Research Station, Agriculture Canada, Lennoxville, Quebec

(45°22' N, 71° 51' W) and the other at La Pocatière Experimental Farm (47° 21' N, 70° 02' W). Soil types were a Danby sandy loam at site I and a Kamouraska clay at site II. Test plots of winter cereal crops were established late in summer on each site in both years (1973-74, 1974-75). The following cereal cultivars — fall wheat (*Triticum aestivum vulgare*) and fall rye (*Secale cereale*) — were seeded broadcast at 135 kg·ha⁻¹ and 110 kg·ha⁻¹, respectively. Fertilizer (N, P₂O₅, K₂O) was applied broadcast and incorporated at a rate of 500 kg·ha⁻¹ of 5-20-20.

Each of the three replicates consisted of four treatments, with the two species forming plots within blocks and the two levels of compaction (none and compacted by snowmobile) being applied across treatments, thereby constituting a split block design. At Lennoxville, the plots (pie shape) were delimited within a circle of 30 m diameter, while at La Pocatière the plots (2m x 5m) forming a replicate were arranged in a conventional rectangular shape. Replicates were contiguous at both sites.

Snow compaction was obtained by subjecting plots to snowmobile traffic (150 passes a week) during the winter season once the snow thickness had attained 10 cm or more to ensure that mechanical damage to underlying vegetation did not occur. The Bombardier and MotoSki snowmobiles which were used on the two sites to compact the snow exerted a track pressure of approximately 0.021 kg·cm⁻². At site I, the snowmobile was driven about half a meter from the inside edge of the plots and at site II, the trail was located in the center of each replicate and crossed the mid point (5 m axes) of each plot. The following summer, plant height was measured at maturity. Using a 50 cm square quadrat, two samples of plant material were taken from each plot and dried for total yield determination. All yields were recorded and converted to kilograms of dry matter per hectare.

Late in the summer of 1973, before seeding, nine soil temperature stations were installed at the Lennoxville site only, three at each of three locations. The three locations were underneath the center of the trail, underneath the center of bare plots with no snow cover, and under the virgin snow cover at the outside edge as the control. A small pit was dug and nylon blocks with embedded thermocouples were inserted horizontally into the pit wall at 10, 20, 30, 40, 50, 60, 75 and 120 cm depths. A 10 cm thick styrofoam panel was vertically installed against the wall with the nylon blocks to minimize heat conduction through the backfill soil. The bare plots were protected by a 1.22 m x 2.44 m plywood panel installed 20 cm from the soil surface. Each snow accumulation was removed on top and around the panel. Late in the fall, nylon blocks were installed at 5 cm intervals from the

ground on a post at three locations in an undisturbed snow area. Nylon blocks were also inserted at 5 cm intervals on the trail as snow accumulated. Snow and soil temperature readings were taken twice a week, usually in the morning. Instantaneous, as well as minimum-maximum air temperature readings were also recorded.

On the two sites, soil samples were taken with a 7.6 cm diameter by 1 m steel core sampler to determine freezing depths and soil moisture. We duplicated the freezing front readings by using the frost penetrometer method developed by Sartz (1966). The gravimetric moisture content (105°C) was measured on 15 cm core sections down to the 75 cm depth. Snow thickness and snow density were measured with the Mount Rose sampler on packed and unpacked areas on days when snowmobiles were run. The effect of the number of snowmobile passes (0 to 7 passes) at slow and fast speed (8 km/h and 48 km/h) on snow density was evaluated for three different thicknesses of fresh snow. Thermal conductivity of snow was also calculated from the equation ($\lambda = CP^2$) developed by Mellor (1963) where specific heat "C" is a constant value (0.006 cal. g⁻¹·deg⁻¹) and "P" is the snow density (g·cc⁻¹). Analysis of variance and Duncan's multiple range tests (Steel and Torrie 1980) were then conducted on the yields and plant height and also on physical characteristics of snow data.

Results

The different winter environment of each location is reflected in air temperature and in snow precipitation (Figures 1 and 2). The mean value of the number of degree days (°C) for the two year period between November and April was -450 for Lennoxville (site I) and -928 for La Pocatière (site II). Mean daily data showed that air temperatures fluctuated less at site II, as this site is tempered by the St. Lawrence River. The two year average total snow precipitation was 287 cm at site I and 340 cm at site II. The 1973-74 season's snowfall was close to normal while that of 1974-75 was substantially below average. Snow profiles and number of days with snow on the ground were much greater at La Pocatière. On that site, the compacted and natural snow thickness differed little because of snow drifting onto the track. Snow cover was 24 days longer on site II.

For the three trials with densities ranging from 0.145 to 0.250, the undisturbed snow cover averaged 9, 18 and 35 cm thick (Table 1). After only a single passage snow thickness was reduced by one half, while snow density increased by 52 percent. It took only four passes of the snowmobile for the snow to reach a maximum density. The increase in snow density by

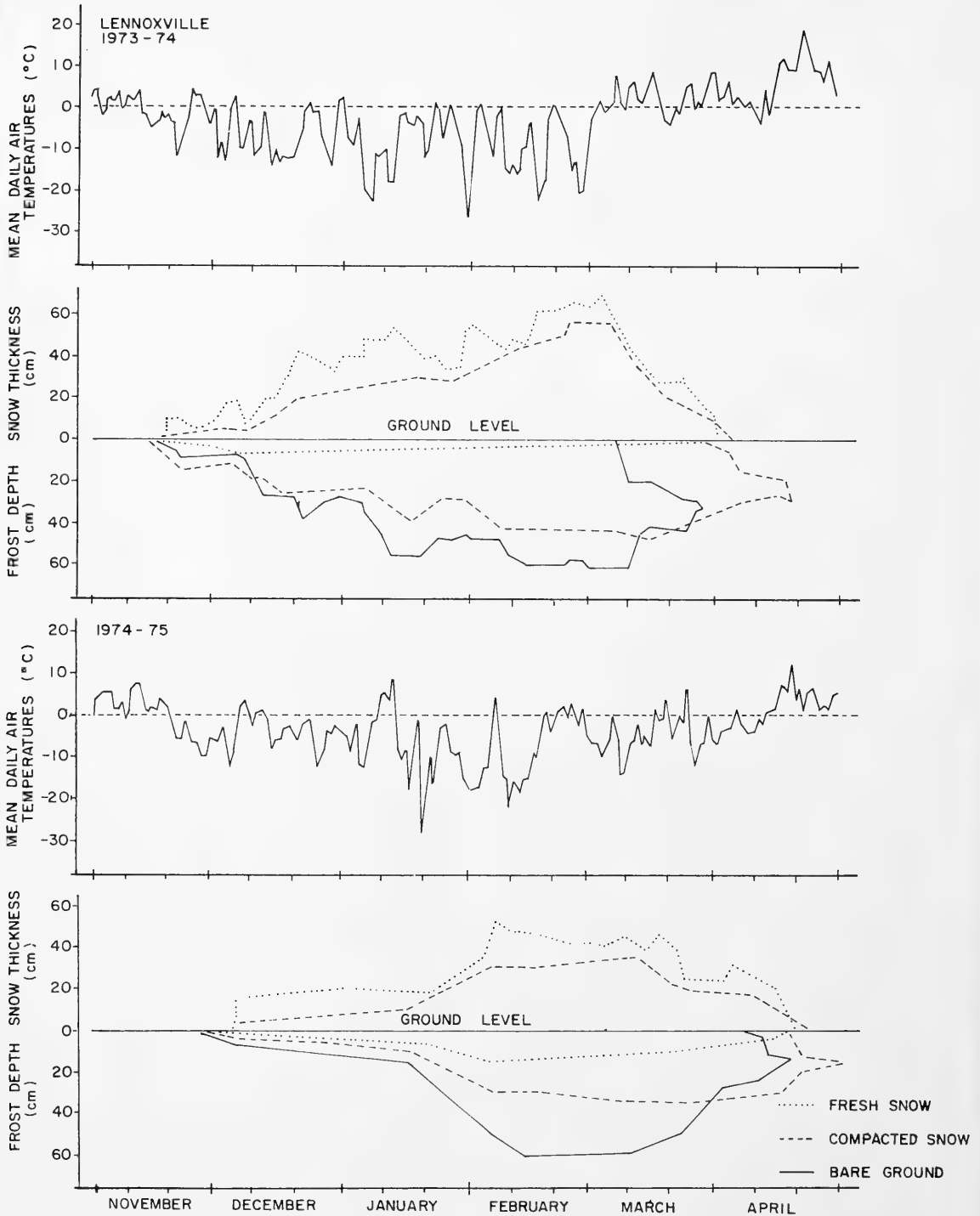


FIGURE 1. Frost depth under fresh snow, compacted snow and bare ground treatments at Lennoxville for winters 1973-74 and 1974-75 as influenced by mean daily air temperature and snow thickness.

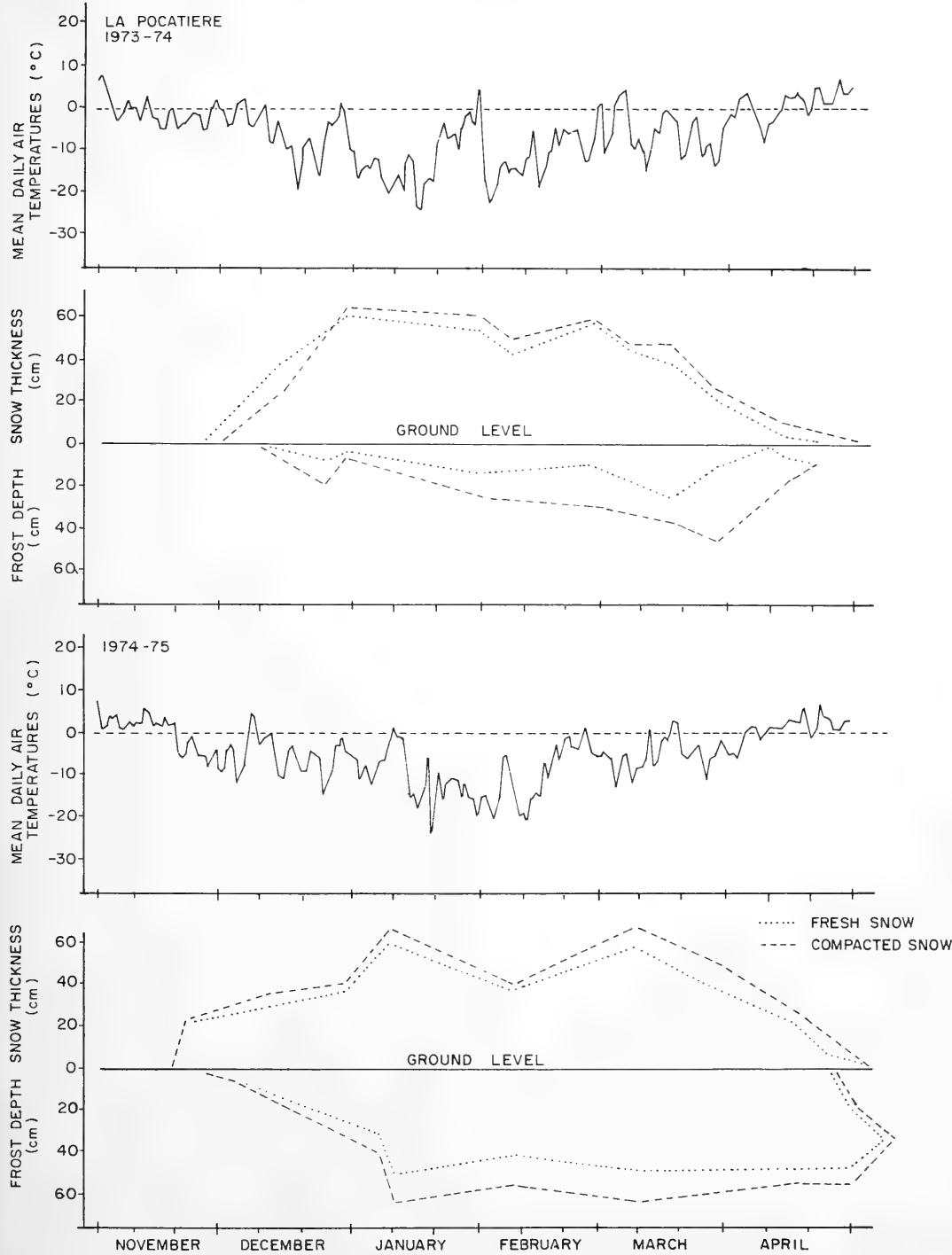


FIGURE 2. Frost depth under fresh snow and compacted snow treatments at La Pocatière for winters 1973-74 and 1974-75 as influenced by air temperature and snow thickness.

snowmobile runs was strongly correlated with its thickness. The thinner snow thickness was associated with higher snow specific gravities. Since values obtained between 0.390 and 0.518 were within the critical snow densities reported by Anderson and Benson (1963), maximum mechanical compaction had occurred after four runs and had therefore begun the metamorphic crystallization toward ice formation. Snowmobile speed had an influence on snow density (Figure 3). After one traverse at slow speed (8 km/h) the density was 0.357 as compared to 0.511 at a higher speed (48 km/h). This was attributed to the fact that fast packing expelled the snow away and the increase of snow density was then accentuated. Snow densities between the two treatments reached equilibrium after seven runs.

From the data reported in Table 1, snow compacted by one pass and by four passes transmitted heat from the soil below at a rate of 2.6 times and 5 times that of undisturbed snow, respectively. For 1973-74 at Lennoxville, the average compacted snow thermal conductivity (λ) within the whole profile was significantly higher than that of undisturbed snow (Table 2). There was a much larger increase in thermal conductivity for the untreated snow between 4 January and 16 March. Snow density doubled in

TABLE 1. Effect of the number of snowmobile runs on snow density ($\text{g}\cdot\text{cc}^{-1}$) at Lennoxville. (Mean of three replicates for three different thicknesses).

Number of runs	Thickness			Mean
	9 cm (-4°C)*	18 cm (-5°C)*	35 cm (0°C)*	
0	0.194	0.250	0.145	0.197 ^e
1	0.356	0.325	0.212	0.298 ^d
2	0.459	0.331	0.248	0.346 ^c
3	0.470	0.334	0.304	0.369 ^b
4	0.518	0.400	0.254	0.390 ^a
5	0.516	0.400	0.300	0.405 ^a
Mean ^a	0.419 ^b	0.340 ^c	0.244	0.334

*Instantaneous air temperature taken during each test for 28 January, 5 February and 25 March, 1974, respectively.

^{a-c}Means within number of runs or within thicknesses followed by the same letter do not differ significantly from one another at the $P = 0.05$ level according to Duncan's Multiple Range test.

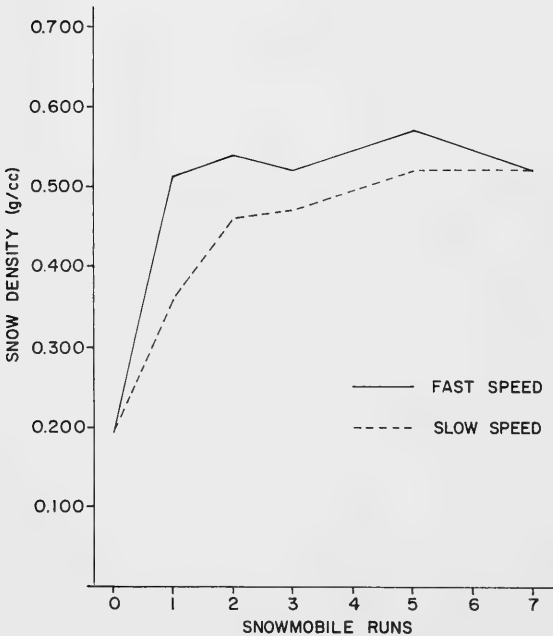


FIGURE 3. Effect of the snowmobile speed (slow and fast) and number of runs on snow density.

natural snow throughout the winter in comparison with an increase of 20 percent within compacted snow.

Snow cover serves as a blanket to insulate the soil from the air, thereby reducing the extremes in temperature variation in the soil when compared to those of air. This damping of temperature fluctuations by snow is a function of snow thickness and thermal diffusivity and the period of temperature oscillations (Mellor 1963). In Figure 4, snow temperature was closely related to snow thickness for both compacted and untreated snow on three consecutive days. Undisturbed snow was an excellent natural thermal insulator during the three-day period. The temperature under the 70 cm of untreated snow rarely fell below -1°C at the soil surface. This confirms the results of Wanek (1971a), Potter (1956) and Bleak (1970) who found that subnivean temperatures hovered around the freezing point under non-track areas. In contrast, mean temperature was 5.5°C colder for the compacted snow treatment. Under sub-zero ambient air temperatures, the increase in thermal conductivity (Table 2) caused by snowmobiles resulted in colder conditions in the snow cover with -4°C as the coldest temperature recorded on day 3 as compared with -1°C under the natural snow cover. The temperature decrease at the soil surface of 1.5°C under the compacted snow during the three-day period was nearly twice the decrease of 0.84°C under the untreated snow. Compaction has produced a significant increase in the slopes of snow temperatures when compared to those of untreated snow during the three-day period. This accelerated heat loss produced some effects on soil properties.

TABLE 2. Effect of snowmobile traffic on density and thermal conductivity of compacted and untreated snow profiles for the winter 1973-74 at Lennoxville. (Mean of three replicates).

	Compacted snow		Untreated snow	
	Density (g·cc ⁻¹)	Thermal Conductivity (10 ⁻³ cal·cm ⁻¹ sec ⁻¹ deg ⁻¹)	Density (g·cc ⁻¹)	Thermal Conductivity (10 ⁻³ cal·cm ⁻¹ sec ⁻¹ deg ⁻¹)
4 January	0.497	0.0163 ^{dc}	0.239	0.0038 ^c
15 January	0.485	0.0155 ^d	0.227	0.0034 ^c
17 January	0.510	0.0171 ^{dc}	0.251	0.0042 ^c
25 January	0.563	0.0209 ^b	0.355	0.0083 ^b
1 February	0.550	0.0200 ^{bc}	0.320	0.0067 ^b
15 February	0.500	0.0170 ^{dc}	0.256	0.0043 ^c
22 February	0.483	0.0154 ^d	0.352	0.0082 ^b
5 March	0.613	0.0248 ^a	0.337	0.0075 ^b
16 March	0.591	0.0230 ^{ab}	0.445	0.0131 ^a
Mean	0.532	0.0157 ^a	0.309	0.0063 ^b

a-d Column values followed by the same letter do not differ significantly from one another at the P = 0.05 level according to Duncan's Multiple Range test.

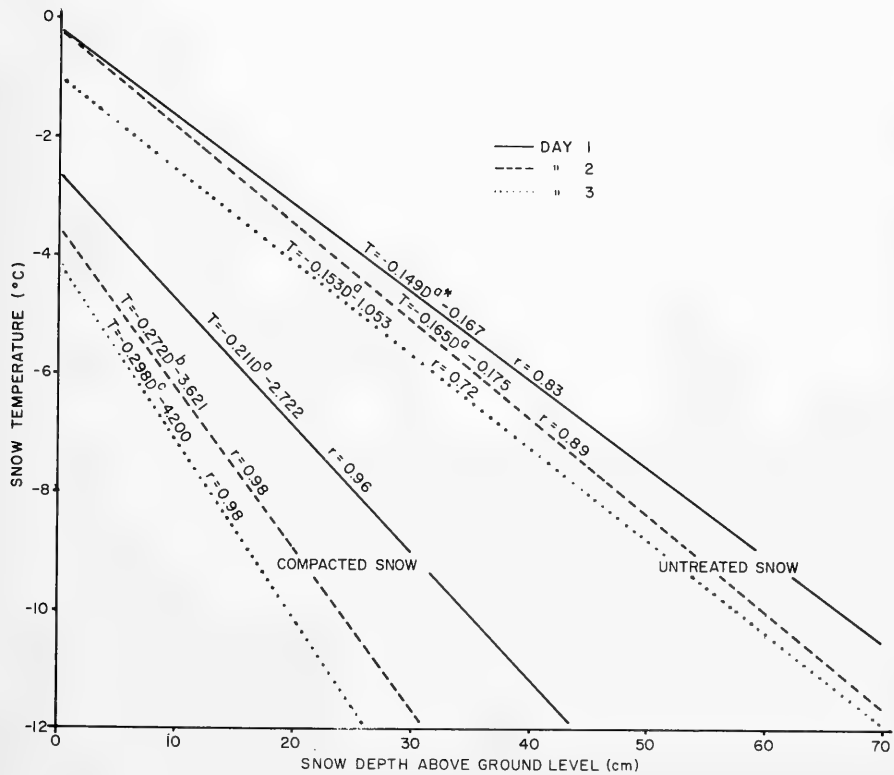


FIGURE 4. Regression equations of snow temperature on snow thickness for compacted and untreated snow treatments. Regression coefficients followed by the same letter do not differ significantly from one another at the P = 0.05 level according to Duncan's multiple range test.

Frost penetration profiles were strongly correlated with the intensity of snowmobile traffic and reached soil depths of 54 cm at Lennoxville and 60 cm at La Pocatière (Figures 1 and 2). Frost penetrated to depths 2 to 5 times those recorded under untouched snow cover. The greatest frost depth measured was found under compacted snow in mid-March. Most of the deep freezing occurred during the months of January and February. As the spring thaw progressed, the soil horizons under compacted snow remained frozen much longer than untreated areas and warm-up lagged significantly even after all the snow had melted completely. Thawing took place from the bottom of the frozen layer as well as from above and began 11 days earlier in snowless plots. Frost lasted, on average, 17 more days in the soil under the snowmobile trail at Lennoxville and 7 days longer at La Pocatière. Figure 5 shows depths of frost penetration at the time of measurement in mid-March of each year for both sites studied. Frost was directly related to climatic and snow conditions. Soil froze more deeply under the center of the tracks, the frost profiles being "V" shaped. The effect of the compaction on frost penetration extended to 1.5 to 1.8 m on either side of the track, decreasing with distance from the center of the trail.

The downward frost penetration underneath the trail increased the moisture content of the frozen

portion of the soil profiles (Table 3). The dark line within the data represents the frost front and also delineates the zone of increased moisture content in the frozen layer, apparently caused by migration from the unfrozen layer below. The difference between untreated and compacted snow was the increase in snow density caused by the snowmobile. In the frozen portion of the soil the average moisture content often decreased with the depth of freezing. Upon thawing the average moisture content (untreated and compacted) of the frozen surface (34.5%) approached the saturation point (42%). The moisture content of the unfrozen portion of the Danby soil was in most cases lower than the moisture equivalent value (26%), ranging between 7.1 and 29.9 percent. The same phenomenon took place at the other site in clay with higher average moisture percentages.

The soil temperature profiles shown in Figure 6 compare the mean values of the temperature readings from 10 to 120 cm deep for untreated snow, compacted snow, and bare ground at Lennoxville. Soil temperatures under compacted snow and undisturbed snow did not equilibrate until the first week of May. The soil temperature profiles under compacted and undisturbed snow in 1973-74 converged almost 29 days earlier than in 1974-75 because the snow had melted completely on the site. The explanation involves difference in snow

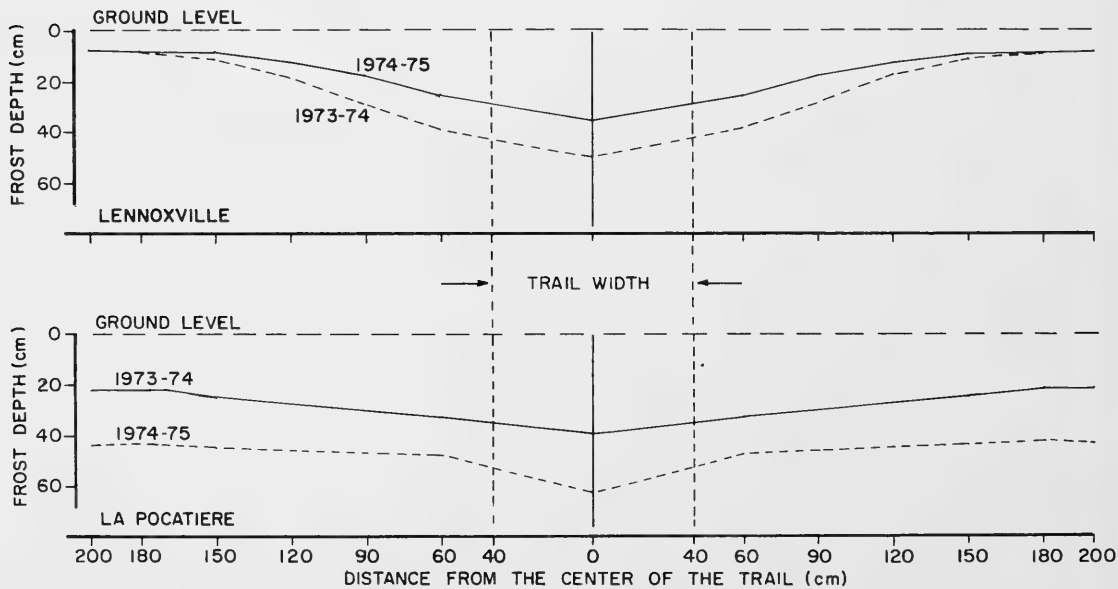


FIGURE 5. Cross-sectional profiles of the depth of frozen soil boundary taken in March of the two years at Lennoxville and La Pocatière.

TABLE 3. Soil moisture profiles (percent) with depth of frozen soil boundary* throughout the winter 1973-74 at Lennoxville for untreated and compacted snow treatments (mean of three replicates).

Depth of sampling (cm)	Date								
	12 December	27 December	4 January	10 January	24 January	4 February	19 February	20 March	8 April
UNTREATED SNOW									
0-15	29.9	35.4	35.2	39.2	39.9	35.5	37.2	53.3	21.7
15-30	27.2	24.5	23.0	18.2	20.5	22.6	19.8	21.7	16.6
30-45	23.3	16.9	22.7	14.7	19.6	15.8	15.3	21.6	17.6
45-60	20.3	10.7	25.6	17.6	8.9	12.1	13.4	10.0	12.2
60-75	17.2	13.5	17.0	14.8	7.1	9.2	8.5	8.8	12.4
COMPACTED SNOW									
0-15	21.5	35.4	40.5	37.1	45.9	30.9	32.9	34.7	23.8
15-30	24.5	25.0	22.8	32.3	35.5	24.6	25.8	23.0	18.8
30-45	26.8	29.1	9.9	24.7	37.7	29.0	29.9	10.7	18.9
45-60	18.2	24.5	7.4	18.2	18.1	15.1	15.3	15.4	15.0
60-75	14.5	16.1	11.8	16.8	16.2	10.3	10.8	7.1	16.7

*Frozen soil over the heavy line.

accumulation at ground level (Figure 1). Permanent freezing temperatures in the soil were not reached until mid-February 1973-74 and not before the third week of January in 1974-75 (Figure 6). Because of the lower average snowfall and later accumulation of significant quantities in 1974-75, the soil froze earlier than in 1973-74. As a result, the period with freezing soil temperatures was much longer in 1974-75. The hatched bands illustrate the influence of the compacted snow on soil temperatures. Because of significant heat loss underneath the compacted snow, the temperature under the track was always less than that under undisturbed snow. Soil temperature underneath the trail fell below freezing as early as December and stayed there until the end of April. Finally, the temperatures of the bare ground plots were lower and fluctuated more due to the lack of insulation.

The yields and plant height for wheat and rye cereal crops are presented in Table 4. Snowmobile traffic had no significant effect on the yield and height of the two winter cereals (Table 5). Cereal yields were higher at La Pocatière (site II) due to a more productive soil. At this site, yields and height were much lower in 1975 because of late seeding (beginning of September). The years had a positive effect on yield and height at site II, but no significant interactions were found between snowmobile traffic and years and between snowmobile treatments and species.

Discussion

Snowpacking by snowmobile traffic and the subsequent increase in thermal conductivity were the factors responsible for the release of heat flow from

the soil. Snowmobiles caused a dramatic increase in snow density and a decrease in its thickness. It took only four passes with a snowmobile to increase the snow density to a maximum level, at which point heat was transmitted from the soil below at a rate of five times that of undisturbed snow, thereby causing abnormally cold conditions deep in the snow profile. The temperature gradient in compacted snow was greater than in fresh snow. This resulted in lower soil temperatures underneath the snowmobile trail and deeper frost penetration. If the snow cover is sufficiently thick, frost may be drawn from the soil by the warmth of the earth throughout the winter (Figure 1). This confirms the results of Hart and Lull (1963) who showed that snow thickness of more than 45 cm will prevent frost penetration of the soil.

The removal of snow or bare ground at Lennoxville caused frost to penetrate deeper in the soil (Figures 1 and 2). From the beginning of the winter to the thawing period, soil froze an average of 16 cm deeper in snowless plots than in plots under compacted snow. The ratios of frost penetration rate ($\text{cm}\cdot\text{day}^{-1}$) in compacted snow and bare ground to that of untreated snow were 4:1 and 8:1, respectively. Even though the snow under the snowmobile trail was compacted, it provided some insulative protection to the soil. However, bare soil thawed twice as fast as the compacted snow treatment. Due to increased density and consequent changes in thermal conduction and crystal structure of compacted snow, snowmobile trails melted more slowly than untreated snow, averaging 3 days longer at Lennoxville and 5.5 days at La Pocatière. Thermal conductivity of disturbed snow was 2.5 times greater with a density 58% higher than

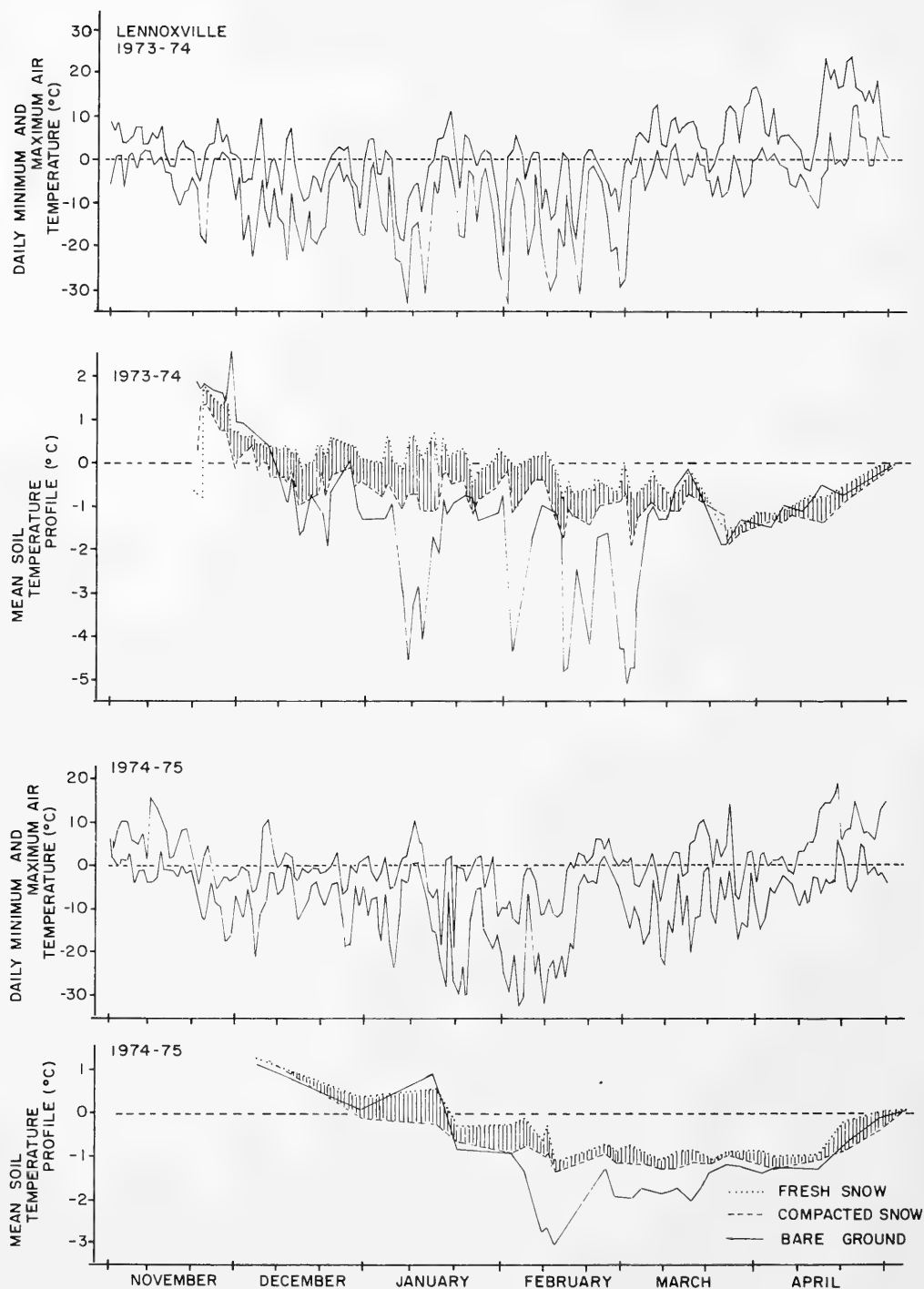


FIGURE 6. Effect of snow compaction and bare ground on soil temperature profiles at Lennoxville for 1973-74 and 1974-75.

TABLE 4. Total yields (kg·ha⁻¹) and plant height (cm) obtained from winter wheat and rye cereals affected by snowmobile traffic at the two sites for the two years. (Mean of three replicates).

	Lennoxville (I)				La Pocatière (II)			
	1974		1975		1974		1975	
	Snomobile traffic	Check	Snowmobile traffic	Check	Snowmobile traffic	Check	Snowmobile traffic	Check
YIELD								
Wheat	7 093	6 352	6 822	8 561	10 765	17 564	4 808	5 202
Rye	7 588	9 495	8 146	13 316	14 747	15 016	4 485	5 346
Mean	7 340	7 923	7 484	10 938	12 756	16 290	4 647	5 274
PLANT HEIGHT								
Wheat	90	91.7	103.3	112.7	92.7	99.2	76.0	76
Rye	147.7	150.3	166.3	170	137.7	126.7	117.7	117
Mean	118.8	121	135.8	141.3	115.2	113	96.8	96.5

TABLE 5. Effect of snowmobile traffic on yield and plant height of winter wheat and rye cereals at the two sites for the two years.

Source of variation	Degrees of freedom	Lennoxville (I)		La Pocatière (II)	
		yield	height	yield	height
Replicates (R)	2	NS	NS	NS	NS
Species (S)	1	*	*	*	*
E(a)·S×R	2				
Treatments (T)	1	NS	NS	NS	NS
T×S	1	NS	NS	NS	NS
E(b)·R×T+R×S×T	4				
Years (Y)	1	NS	NS	*	**
E(c)·Y×R	2				
Y×S	1	NS	NS	NS	NS
E(d)·Y×S×R	2				
T×Y	1	NS	NS	NS	NS
T×S×Y	1	NS	NS	NS	NS
E(e)·T×Y×R+R×S×T×Y	4				
Total	23				

** Effects significant at level P = 0.01
* Effects significant at level P = 0.05
NS Effects not significant

that of untreated snow (Table 2).

The most significant hydrologic effect of deep soil freezing under compacted snow treatments may have been the additional days required for complete thawing in comparison to undisturbed snow cover. Freezing and thawing exerted a considerable influence on the water relationship of soils (Table 3). The concentration of water at or near the soil surface where it becomes immobilized by freezing is one of the important characteristics of frozen soils. The moisture content of frozen soil approached the saturation point with a range of two to three times higher than the unfrozen portion of the soil profile. Thus the snowmobile had a significant influence on soil moisture profile equilibrium. The interaction of snow compaction and the water buildup in the frozen layer of the soil has been observed to cause reduction of plant regrowth. Pesant et al. (1978) noted that the increase in soil water content during winter was the variable which had the greatest impact on alfalfa

survival. Tests conducted by Pesant et al. (1985) on established forage stands in farmers' fields revealed a significant reduction in yield and legume stands following snowmobile traffic. No significant yield reduction of winter wheat or winter rye was produced by the snowmobile in the present study.

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Literature Cited

- Anderson, D. L., and C. S. Benson. 1963. The densification and diagenesis of snow. Pp. 391-411 in *Ice and snow*. Edited by W. D. Kingery. M.I.T. Press, Cambridge, Massachusetts.
- Bleak, A. T. 1970. Disappearance of plant material under a winter snow cover. *Ecology* 51: 915-917.
- Foresman, C. L., D. K. Ryerson, R. N. Walejko, W. H. Paulson, and J. W. Pendleton. 1976. Effect of snowmobile traffic on bluegrass (*Poa pratensis* L.). *Journal of Environmental Quality* 5: 129-131.
- Hart, G., and H. W. Lull. 1963. Some relationships among air, snow and soil temperatures and soil frost. Northeastern Forest Experimental Station Research Note NE-3: 1-4.
- Mellor, M. 1963. Polar snow: a summary of engineering properties. Pp. 528-559 in *Ice and Snow*. Edited by W. D. Kingery. M.I.T. Press, Cambridge, Massachusetts.
- Newman, P. W., and H. G. Merriam. 1972. Ecological effects of snowmobiles. *Canadian Field-Naturalist* 86(3): 207-212.
- Pendleton, J. W., and R. N. Walejko. 1972. Effects of traffic on non-forest vegetation. Progress report, University of Wisconsin, Madison Cooperative Research, Agronomy and Experimental Farms, Madison, Wisconsin.
- Pesant, A. R., R. Bolduc, et R. Drapeau. 1978. Effets de certains facteurs climatiques et édaphiques sur la survie à l'hiver de la luzerne au Québec. *Canadian Journal of Plant Science* 58: 448-458.
- Pesant, A. R., C. Fernet, L. Belzile, and J. L. Dionne. 1985. Effects of snowmobile traffic on yield and botanical composition of forage stands in Quebec. *Canadian Journal of Plant Science* 65: 543-552.
- Potter, L. D. 1956. Yearly soil temperatures in eastern North Dakota. *Ecology* 37: 62-70.
- Sartz, R. S. 1966. A test of three indirect methods of measuring depth of frost. *Soil Science* 104(4): 273-278.
- Steel, R. G. D., and J. H. Torrie. 1980. Principles and procedures of statistics: a biometrical approach. Second edition. McGraw-Hill, New York.
- Schmid, W. D. 1971. Modifications of the subnivean microclimate by snowmobiles. Pp. 251-257 in *Proceedings of the snow and ice symposium*. Co-operative Wildlife Research Unit, Iowa State University, Ames, Iowa.
- Walejko, R. N., J. W. Pendleton, W. H. Paulson, R. E. Rand, R. G. D. Tempas, and D. A. Schlough. 1973. Effect of snowmobile traffic on alfalfa. *Journal of Soil and Water Conservation* 28(6): 272-273.
- Wanek, W. J. 1971a. Snowmobiling impact on vegetation, temperature and soil microbes. Paper presented at the Snowmobile and off-the-road vehicle research symposium, Michigan State University, East Lansing, Michigan, June, 1971. Technical report no. 8: 117-30.
- Wanek, W. J. 1971b. Paper presented at Conference on snowmobiles and all-terrain vehicles, University of Western Ontario, London, Ontario. 237 pp.
- Wanek, W. J. 1972. A continuing study of snowmobiling in northern Minnesota (Final research report for 1971-1972). The Center for Environmental Study, Bemidji State College, Bemidji, Minnesota.
- Wanek, W. J. 1973. A continuing study of snowmobiling in northern Minnesota (final research report for 1972-1973). The Center for Environmental Study, Bemidji State College, Bemidji, Minnesota.

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Growth of the Snow Goose, *Chen caerulescens*, Colony at McConnell River, Northwest Territories: 1940-1980

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MacInnes, C. D., and R. H. Kerbes. 1987. Growth of the Snow Goose, *Chen caerulescens*, colony at McConnell River, Northwest Territories: 1940-1980. *Canadian Field-Naturalist* 101(1): 33-39.

The McConnell River Snow Goose (*Chen caerulescens*) colony apparently was established in the early part of this century. Historical population estimates and recent counts from aerial photographs showed very rapid growth, from about 7000 nesting pairs in 1941 to 163 000 in 1973, levelling off thereafter. Local reproduction cannot account for the rapid growth, and both immigration and emigration are thought to have occurred. Feeding in croplands during migration and improved habitat in winter may have led to greater survival and perhaps to larger numbers of non-breeders on increasingly crowded nesting areas. This overcrowding, combined with unfavorable conditions as in a late spring, might help the birds overcome their normal site tenacity to make a mass relocation.

Key Words: Snow Goose, *Chen caerulescens*, colony size, census, Northwest Territories.

The number of Lesser Snow Geese (*Chen c. caerulescens*) breeding in the Canadian arctic has increased considerably over the past quarter century (Kerbes 1975, 1982, 1983, 1986; Kerbes et al. 1983; Boyd et al. 1982). That an increase had occurred was noted only in retrospect, and there are relatively few data documenting size of particular colonies over long periods. In this paper, we describe the historical growth of the colony at McConnell River, Northwest Territories (60°50'N, 94°25'W). This colony started around 1910 and grew to 163 000 breeding pairs in 1973, then levelled off. We discuss possible reasons for the increase and mechanisms by which it could have occurred.

Methods

Biologists spent part or all of the summer near the mouth of the McConnell River in 1954, 1959-61, 1964-73 and 1975-78. Thus, direct ground observations were available for most years of rapid colony growth. The numbers and distribution of nesting birds on the colony were determined accurately with aerial photography in 1972, 1973, 1977, 1978 and 1980 (Kerbes 1975, 1982).

To estimate colony size in earlier years, people who had visited the colony were asked to outline former boundaries of the colony on a map (Figure 1). They drew maps for various years in 1941-1971, using their field notes and small-scale aerial photographs to help delineate habitat boundaries. Before 1966, most of the colony boundaries were quite distinct. Dense nesting by Snow Geese ended abruptly, often at wet areas unsuitable for nesting. Beyond these edges, a few Snow Goose nests were widely scattered (usually more than 500 m apart). Boundary expansions up to 500 m

might go unnoticed for a season or two, but the results show such extensive expansion that small errors are negligible.

After 1966, much colony expansion took place in areas much wetter than the original colony site between the north and south branches of the river. In the new areas, nesting was much less dense, except in small, drier sites. Therefore it was more difficult to define colony boundaries for later years. In 1971, the edge of the colony was mapped on small-scale aerial photographs carried into the field.

After determining boundaries, we estimated colony size by extrapolating the 1972 nest density for the appropriate area (Figure 2). C. von Barloewen (personal communication) made a special attempt to estimate total nests on the ground in 1971. Sampling points were located approximately 1 km apart throughout the colony. From each point, the position of every nest within a 100 m radius was determined using a transit. Densities for each sample plot were calculated and extrapolated to the total colony area.

Results

Numerical growth (Figure 3) was documented by historical estimates, estimates based on boundaries and 1972 core densities (Figures 1 and 2), and by aerial photography.

Local Inuit knew of a small Snow Goose colony at the McConnell River as early as 1910 (Kerbes 1982), but Preble (1902) did not report any from a visit in August 1900. The first estimate of size was made by Angus Gavin (*in* Cooch 1963) in 1941, when he reported 14 000 birds (or 7000 pairs, given no non-breeders). E. F. Bossenmaier's (*in* Hanson et al. 1972) estimate of 50 000 pairs in 1969 (#6, Figure 3) was

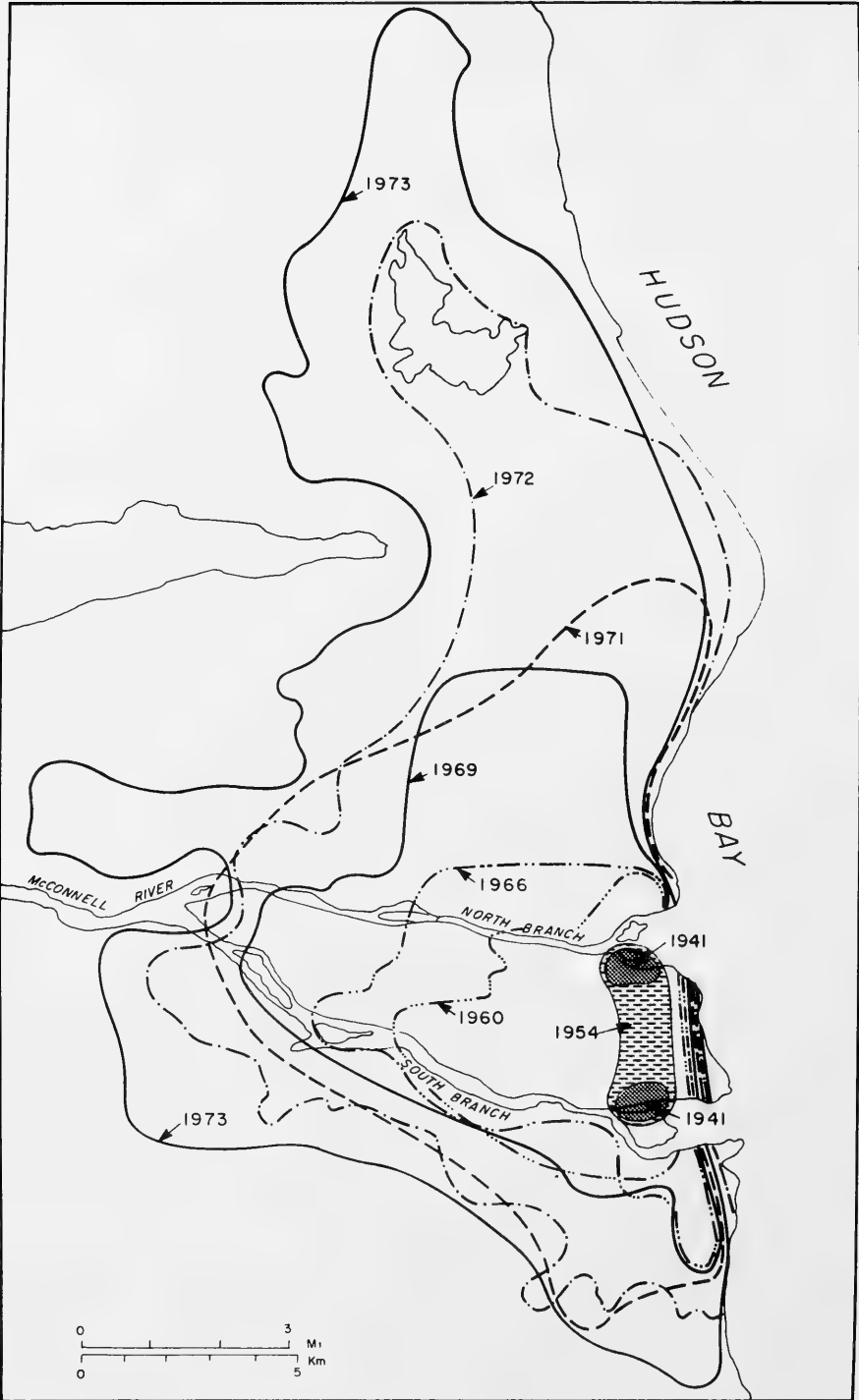


FIGURE 1. Boundaries of the McConnell River Snow Goose colony in various years up to 1973.

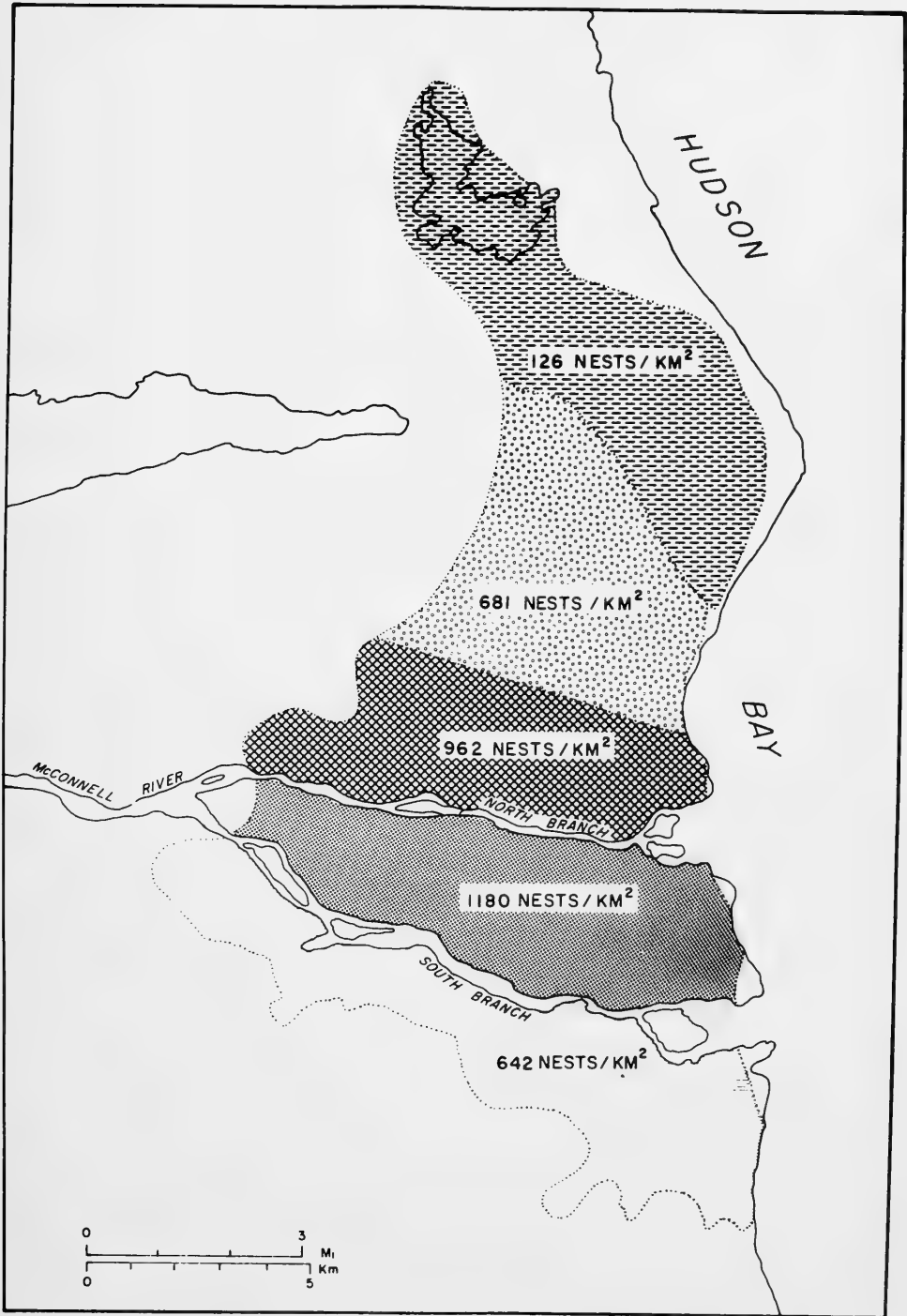


FIGURE 2. Nest densities in the McConnell River Snow Goose colony in 1972: determined from aerial photographs (Kerbes 1975)).

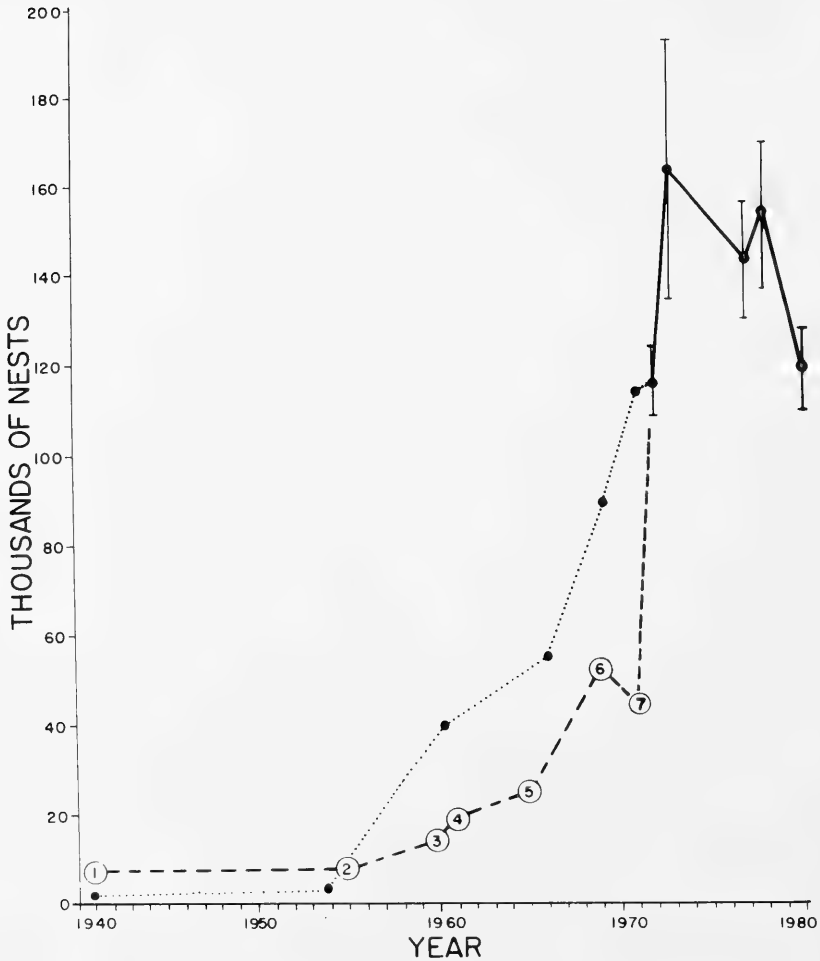


FIGURE 3. Growth of the McConnell River Snow Goose colony. Dashed line up to 1972 joins historic estimates of colony size. Circled numbers show sources of estimates, as follows: 1—Gavin (*in* Cooch 1963), 2—Cooch (*in* Lief 1973), 3—MacInnes (*in* Hanson et al. 1972), 4—Cooch (1963), 5—MacInnes (*in* Lief 1973), 6—Bossenmaier (*in* Hanson et al. 1972), and 7—von Barloewen (personal communication). Data from 1972 on (solid line, including 95% C.I.) are from aerial surveys (Kerbes 1975, and unpublished data). Dotted line indicates estimated size if nest densities from 1972 are applied to colony areas shown in Figure 1 (see text).

improbably high, but it incorporated the whole west Hudson Bay region (Tha'anne to Maguse rivers). Kerbes (1972) found that the McConnell River colony held from 70% to 92% of that region's total nesting birds from 1973 to 1980. The estimate of 50 000 nests for 1969 shows the beginning of the rapid growth period. The historic estimate for 1971 (#7, Figure 3),

however, is difficult to accept, since it seems most unlikely that the colony could have doubled from 53 000 nests in 1971 to 115 000 in 1972. Kerbes (1975) suggested that von Barloewen's estimate for 1971 underestimated the densities of the colony and the size of its northern area.

The estimates based on boundaries and 1972 nest

densities are probably too high for the period of expansion beyond the core area between the branches of the McConnell River. Nest density in the core is not thought to have changed importantly in the 1960s (CDM), and varied $\pm 18\%$ in the 1970s (RHK). However, density continued to increase in newly-occupied areas after settlement (Kerbes unpublished; see also McLandress 1983). Estimates for 1969 and 1971, in particular, would therefore be too high. However, agreement between the two types of estimates (Figure 3) is close enough to establish clearly the general pattern of growth.

The McConnell River colony is an example of exponential population growth. The phenomenal increase in the late 1960s and early 1970s is clearly evident, even with crude methods of estimating numbers prior to 1972. The figures based on aerial photography clearly document the last step in the growth phase, with a significant increase ($P < 0.05$) of 41% from 1972 to 1973. Similarly, the results from aerial photography show a declining trend to 1977 and 1978 followed by a significant decrease ($P < 0.05$) in 1980 (Figure 3). An aerial survey in 1985 (Kerbes unpublished) indicated a return to about 130 000 pairs.

Discussion

Although the McConnell River colony is possibly the oldest and largest on western Hudson Bay, its enlargement is not unique; Snow Geese have also increased elsewhere (Kerbes 1975; Kerbes et al. 1983), and new colonies have been formed in recent times (e.g. the La Perouse Bay colony near Churchill probably was established in the 1950s (Kerbes 1975); see also McLaren and McLaren (1982)). However, the McConnell colony grew at an unusually rapid rate. Boyd et al. (1982) summarized several estimates of growth for the Hudson Bay population, all indicating roughly a 5%/year increase from 1965 to 1980. At this rate, the McConnell colony would have grown, between 1965 and 1973, from 50 000 to 74 000 pairs (starting with extrapolated estimate, Figure 1), or from 24 000 to 37 000 (starting with historical estimate #5, Figure 1). The aerial surveys, however, show 130 000 to 190 000 breeding pairs in 1973.

The reason for the general increase in Snow Geese may be due to conditions on the migration routes and wintering grounds. The geese feed in cropland along their migratory routes for longer portions of the fall than in the past; this may help preserve the quality of the southern wintering areas. In addition, from the late 1940s Snow Geese have begun to exploit improved pasture and vast rice-fields in their wintering areas (Hanson et al. 1972). Boyd et al. (1982) agreed that the increase in numbers was

probably due to a decline in mortality rate rather than an increase in recruitment, despite the larger numbers of birds being shot by hunters.

The traditional eastern arctic breeding area of Snow Geese is on Baffin and Southampton islands. It has been suggested (Hanson et al. 1972) that the McConnell River colony may have been settled by birds from the Boas River colony on Southampton Island, since those birds migrate along that coast and have similar colour-phase ratios (Cooch 1961). Due to isostatic rebound in western Hudson Bay since the last glacial period, the areas now colonized may have become available for occupancy only in the last 250 years (Sim 1960; Hanson et al. 1972), although areas now farther inland may have been suitable earlier. The initial attractiveness of west Hudson Bay may have been related to habitat and climatic factors, since that area is currently warmer and has an earlier nesting season than the more northern colony sites (Kerbes 1975). Earlier nesting results in higher clutch sizes (Davies and Cooke 1983). Climatic factors may be critical to nesting success in birds which have a long nesting cycle in a short arctic summer (Davies and Cooke 1983; Raveling 1978).

Female Snow Geese are highly philopatric, returning to their natal area to breed, and even nesting near the same initial nest site in subsequent years (Cooke et al. 1975; Cooke and Abraham 1980). It is therefore necessary to account for both the establishment of new colonies and, in particular, the rapid increase at McConnell River in the late 1960s and early 1970s.

Occasionally, a female will change her nesting area (Cooke et al. 1975), and Geramita and Cooke (1982) documented an incident at the La Perouse Bay colony in which 900 foreign pairs established themselves in one nesting season. They suggested that these birds formerly nested in a nearby area, and when faced with unsuitable nesting conditions at that site had the choice of waiting until conditions changed (resorbing egg follicles as they waited) or moving to another site. The high degree of female philopatry suggests it is normally more advantageous to wait at a formerly-occupied site, but the formation of new colonies and expansions in recent times suggest that this sort of event may occur more often than formerly suspected. Recent discovery of new colonies in northern Keewatin and increased numbers in the central Arctic thus may have resulted from emigration from west Hudson Bay (Dzubín 1979; McLaren and McLaren 1982; Kerbes et al. 1983).

Such mass movements into new areas may be facilitated when a) the birds originally nested nearby, b) they are familiar with the new site because they have spent summers there, and c) when there already is an

established colony at the new site. The west Hudson Bay region (a coastal strip of about 120 km, well separated from other Snow Goose nesting regions) includes several small colonies 20 to 70 km distant from the main one at the McConnell River site, and there are often "vagrant", more or less solitary nesters scattered in between (Kerbes 1975, 1982).

Rapid growth of a colony could involve a consolidation of birds from such a region, particularly when a large portion of the area is familiar to birds for summer feeding or moulting. Cooke and Abraham (1980) showed that females normally returned to nest near their natal nesting site, but that if there was a shift it was usually to a site closer to the post-hatch feeding area. Furthermore, non-breeders may move long distances in the post-hatch period to areas not used by families, where they spent the summer and moult (Hanson et al. 1972; Dzubin 1979; Abraham 1980; Kerbes 1982). These "moult migrations" may set the stage for immigration to an area which is known by the birds to have suitable habitat. Lastly, colony growth may be especially rapid if there are a few pioneer pairs at the site already, signalling that the area is suitable. When there are large numbers of non-breeders, there might be a large pool of birds more "willing" to move once a new site has begun to be occupied. (This mechanism of rapid colony growth is known to operate in Herring Gulls, *Larus argentatus*; Kadlec and Drury 1968.)

Although it is difficult to document the number of non-breeders in Snow Geese, one estimate (Hanson et al. 1972) suggested the McConnell colony had the largest proportion of non-breeders (25%) of three Hudson Bay colonies studied. (Cape Henrietta Maria, with 40 000 birds, had 18% non-breeders, while the smallest and newest colony at La Perouse Bay had only 12%, among 5000 birds.) This, along with apparent degradation of the McConnell habitat during the 1960s and 1970s (Lieff 1973; Kerbes 1975, 1982), may have contributed to the levelling off of colony size in the 1980s. The history of the McConnell River colony indicates the value of monitoring accurately the numbers of nesting geese in an entire region with aerial photography.

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Literature Cited

- Abraham, K. F. 1980. Moults migration of Lesser Snow Geese. *Wildfowl* 31: 89-93.
- Boyd, H., G. E. J. Smith, and F. G. Cooch. 1982. The Lesser Snow Goose of the eastern Canadian arctic: their status during 1964-79 and their management from 1981 to 1990. Canadian Wildlife Service Occasional Paper 46. 25 pp.
- Cooch, F. G. 1961. Ecological aspects of the Blue-Snow Goose complex. *Auk* 78: 72-89.
- Cooch, F. G. 1963. Recent changes in distribution of the colour phases of *Chen c. caerulescens*. International Ornithological Congress Proceedings XIII: 1182-1194.
- Cooke, F., and K. F. Abraham. 1980. Habitat and locality selection in Lesser Snow Geese: the role of previous experience. Acta XVII Congressus Internationalis Ornithologicus: 998-1004.
- Cooke, F., C. D. MacInnes, and J. P. Prevett. 1975. Gene flow between breeding populations of Lesser Snow Geese. *Auk* 92: 493-510.
- Davies, J. C., and F. Cooke. 1983. Annual nesting productivity in Snow Geese: prairie droughts and arctic springs. *Journal of Wildlife Management* 47: 291-296.
- Dzubin, A. 1979. Recent increases of Blue Geese in western North America. Pp. 141-175 in *Management and biology of Pacific Flyway geese*. Edited by R. L. Jarvis and J. C. Bartonek. OSU Book Stores Inc., Corvallis, Oregon.
- Geramita, J. M., and F. Cooke. 1982. Evidence that fidelity to natal breeding colony is not absolute in female Snow Geese. *Canadian Journal of Zoology* 60: 2051-2056.
- Hanson, H. C., H. G. Lumsden, J. J. Lynch, and H. W. Norton. 1972. Population characteristics of three mainland colonies of Blue and Lesser Snow Geese nesting in the southern Hudson Bay region. Ontario Ministry of Natural Resources Fish and Wildlife Research Report No. 92. 38 pp.
- Kadlec, J. A., and W. H. Drury. 1968. Structure of the New England Herring Gull population. *Ecology* 49: 644-676.
- Kerbes, R. H. 1975. The nesting population of Lesser Snow Geese in the eastern Canadian arctic: a photographic inventory of June 1973. Canadian Wildlife Service Report Series No. 35, Ottawa. 47 pp.
- Kerbes, R. H. 1982. Lesser Snow Geese and their habitat on west Hudson Bay. *Le Naturaliste canadien* 109: 905-911.
- Kerbes, R. H. 1983. Lesser Snow Goose colonies in the western Canadian Arctic. *Journal of Wildlife Management* 47: 523-526.
- Kerbes, R. H. 1986. Lesser Snow Geese, *Anser c. caerulescens*, nesting in the western Canadian Arctic in 1981. *Canadian Field-Naturalist* 100(2): 212-217.
- Kerbes, R. H., M. R. McLandress, G. E. J. Smith, G. W.

- Beyersbergen, and B. Godwin.** 1983. Ross' Goose and Lesser Snow Goose colonies in the central Canadian arctic. *Canadian Journal of Zoology* 61: 168-173.
- Lieff, B. C.** 1973. The summer feeding ecology of Blue and Canada Geese at the McConnell River, N.W.T. Ph.D. thesis, University of Western Ontario, London, Ontario. xvii + 203 pp.
- MacInnes, C. D., R. A. Davis, R. N. Jones, B. C. Lieff, and A. J. Pakulak.** 1974. Reproductive efficiency of McConnell River small Canada Geese. *Journal of Wildlife Management* 38: 686-707.
- McLandress, M. R.** 1983. Temporal changes in habitat selection and nest spacing in a colony of Ross' and Lesser Snow Geese. *Auk* 100: 335-343.
- McLaren, P. L., and M. A. McLaren.** 1982. Migration and summer distribution of Lesser Snow Geese in interior Keewatin. *Wilson Bulletin* 94: 494-504.
- Preble, E. A.** 1902. A biological investigation of the Hudson Bay region. *North American Fauna* 22: 1-140. [U.S. Department of Agriculture, Division of Biological Survey.]
- Raveling, D. G.** 1978. The timing of egg laying by northern geese. *Auk* 95: 294-303.
- Sim, V. W.** 1960. Maximum post-glacial marine submergence in northern Melville Peninsula. *Arctic* 13: 178-193.

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Relations of Small Mammals to Forest Management in Northern Maine

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The effects of forest management practices on small mammals were investigated across northern Maine in the summer of 1982. Fourteen different forest types, grouped as early successional stages, mature conifer, and mature mixed or hardwood, were studied. Ten species of mammals were collected. Relative abundance, species richness, diversity, and evenness for each habitat and niche breadth for individual species were calculated. Unsprayed spruce-fir stands in which all canopy trees had been killed by Spruce Budworm, *Choristoneura fumiferana*, had abundant, rich, and diverse small mammal communities. Spruce-fir stands with low budworm infestation had abundant but low diversity communities, whether sites had been sprayed with insecticide or not. Clearcut sites sprayed with herbicide or burned one to four years previously had low abundance but retained moderate diversity and richness. *Peromyscus maniculatus* (Deer Mouse) dominated a five-year old burn. *Microtus chrotorrhinus* (Rock Vole) was found in two habitats previously considered atypical for this species in Maine.

Key Words: Small mammals, northern forest management, Maine, diversity, relative abundance, *Peromyscus maniculatus*, Deer mouse, *Microtus chrotorrhinus*, Rock Vole, *Blarina brevicauda*, Short-tailed Shrew, *Clethrionomys gapperi*, Southern Red-backed Vole, *Sorex cinereus*, Masked Shrew, *Microtus pennsylvanicus*, Meadow Vole.

The impact of various forest management practices on wildlife is an important issue in Maine, which has 90% of its total land area in forests. Research on the relationships between forest management and wildlife often concentrates on game species. The main purpose of forest practice in the state is "to improve, maintain, and protect forest land" primarily as a source of wood products, but there has been increasing attention given to the protection of wildlife and recreation resources of the forest lands (Society of American Foresters 1974). There has been relatively little effort focused on nongame mammals in Maine (Richens 1974; Monthey and Soutiere 1985).

The primary aim of this study was to investigate how distribution, abundance, and community structure of small mammals are influenced by different forestry practices. Because the Spruce Budworm, *Choristoneura fumiferana*, is a major pest causing widespread tree mortality and is the target of major control efforts, small mammals of forest stands with different degrees of tree morbidity due to Spruce Budworm infestation were included in this study. The small mammals in stands which had received treatments of insecticides, herbicides, or which had been clearcut or burned were studied and compared with other stands which remained intact and untreated.

Study Sites and Methods

Most of Maine is in the Spruce-Fir Forest Region (Figure 1). A small portion of the southeast is

described by Lull (1968) as Northern Hardwoods and the southern tip of the state is White Pine-Northern Hardwood Forest. The present study was conducted from 15 June to 7 August 1982 in four areas denoted on Figure 1. These areas were 1. Washington Co., Moosehorn National Wildlife Refuge, Baring Unit, 2. Washington Co., Topsfield and Brookton, near Baskahagen Lake, 3. Piscataquis Co., Baxter State Park, Chesuncook Lake and Telos Lake (T3 and T4 R10 WELS, T3 R12 WELS, and T4 R11 WELS), and 4. Oxford Co., White Mountain National Forest, Stoneham.

The selection of study sites for collecting small mammals was designed to include a variety of forest management practices. Fourteen different forest habitat types were sampled. To facilitate the analysis of data, these habitats were grouped into three general categories: early successional stages, mature conifer, and mature mixed or hardwood stands. Table 1 lists the 14 habitat types and the dominant plants forming the tree, sapling-shrub, and ground layers of vegetation of each.

The management practices on the habitats studied included spraying for Spruce Budworm, spraying for broad-leaved plant control, clearcutting, and clearcutting followed by burning. Uncut conifer stands defoliated by Spruce Budworm, undamaged and unmanaged stands of conifers, a natural burn, and mixed and hardwood forests were sampled for comparisons. The spruce-fir stand treated for budworm was sprayed by air with Sevin (carbaryl)

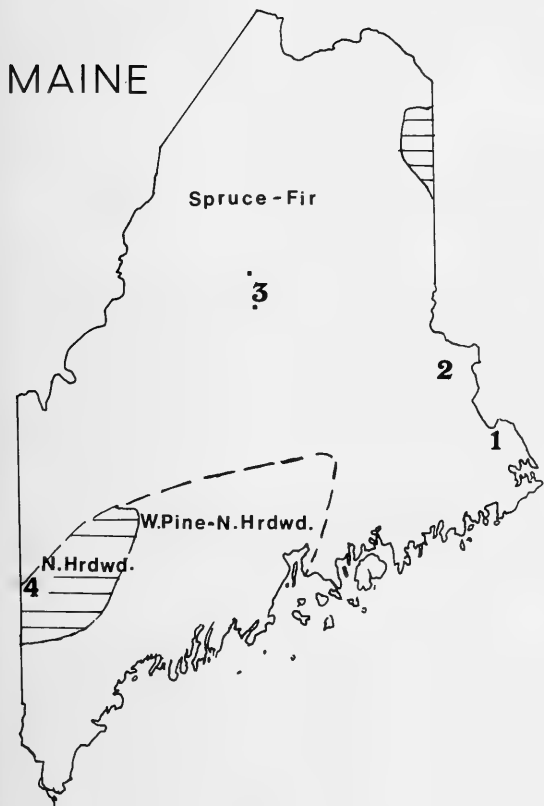


FIGURE 1. Major forest types of Maine with the locations of the four areas of small mammal collections for this study.

twice in the month previous to mammal sampling. The spruce plantation which received the herbicide 2,4,5-T (2,4,5-trichlorophenoxy acetic acid) was clearcut and planted with seedlings in 1978. The herbicide was applied by air in the spring of 1982. Stands with complete defoliation of spruce and fir were located within Moosehorn National Wildlife Refuge and Baxter State Park where insecticides are not used.

Small mammals were collected with lines of commercial snap traps baited with a mixture of peanut butter and rolled oats. Trap lines were either 10 or 20 stations long with 10 meters between stations. Three traps were set at each station and left out for three nights. On most sites two lines were set 20 m apart. Animals were collected each morning and specimens were weighed, measured, and autopsied for sex and reproductive status. Selected specimens were prepared as museum specimens and kept in my own

collection. A total of 5490 trap nights (TN) constituted the field collection effort.

The analysis of trap results was done by habitat, by general forest category, and by species. Relative abundance of animals was measured by numbers caught per 100 TN and relative biomass as body mass in grams per 100 TN. Species richness of communities was the number of species represented. Species diversity was measured by the Shannon index (Pielou 1975) where $H' = -\sum p_i \log_n p_i$. The evenness of apportionment of individuals among species in a habitat or forest category was measured according to

Pielou (1975) where $J' = \frac{H}{\log_n s}$. The niche breadth

of species with respect to habitat types was measured as

by Krebs and Wingate (1976) as $B = \frac{1}{\sum p_i^2}$. The small

mammal communities were further analyzed by trophic levels. All species of shrews are insectivorous. The rodents were separated as grazers-omnivores (*Microtus* and *Clethrionomys*) and as granivore-omnivores (*Peromyscus*, *Zapus*, and *Napeozapus*).

Results and Discussion

Mammal Communities and Forest Management

A total of 297 small mammals representing 10 species were captured. The apportionment of species and individuals among habitats is given in Table 2. The characteristics of the mammal community found on each habitat type are described in Table 3. The relationships between the composition and size of small mammal communities and the forest habitats resulting from different management practices are illustrated by these two tables.

In the defoliated spruce-fir forests, where virtually all spruce and fir trees were killed by Spruce Budworm, the species richness and diversity of small mammals were high. Both of these habitats (1 and 6) were characterized by thick vegetation of ground, forb, and shrub layers. The defoliated forest habitat in the Baxter State Park area (habitat 6) had the greatest relative abundance (23.89/100 TN), almost four times the average abundance (5.36/100 TN). The destruction of the forest canopy of spruce and fir trees by budworm seemed to have a positive effect on the abundance and variety of small mammals. This abundance and variety is presumably related to the promotion of understory vegetation. The same relationship held for bird populations in this area of Maine, where Oliveri and Famous (1983) found total numbers and species richness of breeding birds greater on defoliated spruce-fir plots than on healthy forest plots.

The clearcut spruce-fir forests (Habitat 2) which

TABLE 1. Habitat samples during the survey with the dominant plants in tree (T), shrub and sapling (S), and ground (G) layers of vegetation. Location of the habitat by area numbered on Figure 1 is given in parentheses.

A. Early successional stages:	Dominant Plants
No living canopy of trees.	
1. Defoliated spruce-fir (1)	T— Dead <i>Picea</i> and <i>Abies</i> S— <i>Picea</i> and <i>Abies</i> up to 2 m, <i>Acer</i> , <i>Myrica gale</i> G— <i>Rubus</i> and ferns; dense
2. Clear-cut and burned 1, 2, and 4 years previous (1)	G— Grass, sedge, ferns scattered
3. Natural burn, uncut 5 years previous (3)	S— <i>Betula papyrifera</i> , <i>Prunus pensylvanica</i> , <i>Populus tremuloides</i> , <i>Acer rubus</i> G— Grass, <i>Rubus</i> , <i>Vaccinium</i>
4. Clear-cut spruce-fir 6 years previous (3)	S— <i>Populus tremuloides</i> , <i>Prunus pensylvanica</i> , <i>Alnus rugosa</i> , dense G— <i>Rubus</i> , ferns, grass
5. Clear-cut spruce-fir Herbicide treated 1982 (3)	S— Plantation of <i>Picea</i> , 1-2m tall. G— All vegetation dead.
6. Defoliated spruce-fir (3)	T— Dead <i>Picea</i> S— <i>Picea</i> , <i>Betula</i> G— <i>Rubus</i> , ferns, grass, moss; very dense
7. Clear-cut mixed forest (4)	T— Scattered <i>Prunus</i> , <i>Acer</i> , <i>Betula</i> S— <i>Alnus</i> , <i>Prunus</i> , <i>Populus</i> , <i>Acer</i> G— Grass, Forbs
B. Mature conifer forest	
8. Spruce-fir, untreated (2)	T— <i>Picea rubens</i> , <i>P. glauca</i> , <i>Abies balsamea</i> S— <i>Abies balsamea</i> , <i>Acer pensylvanicum</i> G— Moss, <i>Cornus</i> , <i>Vaccinium</i> , grass.
9. Spruce-fir, Insecticide Sprayed (2)	Same as No. 8
10. Black Spruce (3)	T— <i>Picea mariana</i> G— Moss
C. Mature mixed and hardwood forests	
11. Mature mixed forest (1)	T— <i>Pinus strobus</i> , <i>P. resinosa</i> , <i>Betula papyrifera</i> , <i>Acer rubrum</i> S— <i>Pinus strobus</i> , <i>Acer pensylvanicum</i> , <i>Fagus</i> , sparse G— forbs
12. Mature mixed (3)	T— <i>Betula lenta</i> , <i>B. papyrifera</i> , <i>Populus tremuloides</i> , <i>Acer rubrum</i> , <i>Abies balsamea</i> S— <i>Acer rubrum</i> , <i>A. pensylvanicum</i> ; sparse G— Sparse
13. Mature hardwood forest (3)	T— <i>Acer saccharum</i> , <i>Betula lenta</i> , <i>Fagus grandifolia</i> S— <i>Viburnum acerfolium</i> , <i>Acer</i> G— Forbs, moss; moderate
14. Mature mixed forest (4)	T— <i>Pinus strobus</i> , <i>Tsuga canadensis</i> , <i>Fagus grandiflora</i> , <i>Acer saccharum</i> , <i>Betula lenta</i> , <i>B. papyrifera</i> S— <i>Acer</i> G— Forbs; sparse

TABLE 3. Characteristics of the small mammal communities in 14 habitat types of northern Maine. See text for definitions of the measures used.

Habitat	Species diversity	Species richness	Evenness	Relative abundance
1. Defoliated spruce-fir	1.56	7	0.80	2.37
2. Cut and burned spruce-fir	1.77	7	0.91	2.81
3. Natural burn	0.59	5	0.37	5.97
4. Herbicide treatment, clear-cut	1.09	3	0.99	3.61
5. Untreated, clear-cut	0.82	3	0.75	8.06
6. Defoliated spruce-fir	1.19	6	0.66	23.89
7. Clear-cut, mixed	0.80	3	0.73	2.78
8. Insecticide treatment, spruce-fir	0.67	3	0.61	6.39
9. Untreated, spruce-fir	0.60	3	0.55	6.94
10. Black Spruce	0.0	1	—	4.44
11. Mixed, mature	1.57	5	0.98	1.67
12. Mixed, mature	0.64	2	0.92	3.33
13. Hardwood, mature	1.52	6	0.85	16.11
14. Mixed, mature	0.83	3	0.76	4.44

had been burned within the last 1 to 4 years had very high small mammal species richness and diversity but low relative abundance. These cut and burned plots on the Moosehorn Refuge were small in extent and surrounded by a variety of forested habitat. An edge effect may have been responsible for the richness of the mammal community found here. The larger region of natural burn in the Baxter State Park area (Habitat 3) had average relative abundance and species richness but had the lowest species diversity of the study. This was due to the dominance of one species, *Peromyscus maniculatus* (Deer Mouse), on this habitat.

The newly clearcut mixed forest of the White Mountains (Habitat 7) had the same three species (*Blarina brevicauda*, Short-tailed Shrew; *P. maniculatus*; and *Clethrionomys gapperi*, Southern Red-backed Vole) as the uncut mixed forest adjacent to it (Habitat 14), but a slightly lower relative abundance which was not significantly different ($\chi^2 = 1.38$). In other studies of the effect of clearcutting of northern forests on small mammal populations, the changes in relative abundance are variable, with some studies showing an increase and others showing a decrease or little change in abundance. In conifer forests of north-central Maine, Monthey and Soutiere (1985) found the total catch of small mammals greater in clearcuts and partial cuts than in uncut stands. This difference was due to the increase in three species: *Sorex cinereus*

(Masked Shrew), *Microtus pennsylvanicus* (Meadow Vole), and *Clethrionomys gapperi*. Other species were either less abundant or unchanged. The clearcut areas had greater ground cover vegetation than the uncut conifer stands in their study.

In the same region Soutiere (1979) had similar results. Lovejoy (1975) collected small mammals in the northern hardwood forest of the White Mountains in New Hampshire on areas which had been clearcut 1 to 2, 3 to 4, and 15 to 16 years previously and on an area which had been burned after logging 3 to 4 years previously. All stages of the clearcut areas had total abundance of small mammals very close to two uncut forest areas. The burned area had a relative abundance about one-third that of the clearcut and uncut areas.

Kirkland (1977) found increases in relative abundance of small mammals in recent clearcuts in conifer and hardwood forests in West Virginia. In hardwood forests in Pennsylvania, Kirkland (1978a) found relative abundance was greater on recent clearcuts than on adjacent uncut northern hardwoods and oak forests. *Clethrionomys gapperi* was the main species involved. However, both Krull (1970), trapping in mixed forests in the Adirondack Mountains of New York, and Martell and Radvanyi (1977), trapping in Black Spruce forests of northern Ontario, found lower densities of small mammals in clearcuts compared with uncut stands. On conifer

forest plots in British Columbia, Sullivan (1980) found higher densities of small mammals on clearcuts which had been burned five years previously compared with unburned clearcuts. There, *Peromyscus maniculatus* was the single species responsible for the increase.

Habitat 5, which had been treated with herbicide after having been clearcut four years previously, had significantly lower relative abundance of small mammals than the adjacent unsprayed clearcut areas ($\chi^2 = 6.10$, $p < 0.02$). Both of these habitats (4 and 5) had similar diversity and the same three species (Tables 2 and 3). An increase in small mammal abundance followed the application of 2, 4, 5-T on spruce plantations in West Virginia (Kirkland 1978b). There, the understory of grass and ferns remained alive after herbicide treatment in contrast to the total absence of green understory vegetation on my study site. Spraying of the insecticide Sevin on mature spruce-fir forest had no effect on the small mammal community (Habitats 8 and 9). This conforms to the conclusion of a literature survey on the effects of Sevin in Maine forests (Trask 1982).

The habitats with the highest relative abundance were the defoliated spruce-fir forest (Habitat 6) and the mature hardwood forest (Habitat 13), both in Baxter State Park. The habitats with the lowest relative abundances were the defoliated spruce-fir at Moosehorn Refuge (Habitat 1), the cut and burned spruce-fir (Habitat 2), the herbicide treated clearcut (Habitat 4), the clearcut mixed forest (Habitat 7), and two of the mature mixed habitats (Habitats 11 and 12). The lowest species diversity was in the Black Spruce forest, followed by the natural burn habitat. There is not a significant correlation between relative abundance and species richness ($r = 0.29$) or between relative abundance and species diversity ($r = 0.10$).

The seven habitats in early successional stages had no canopy of living trees but had understory vegetation in the sapling-shrub and ground layers. The small mammal communities on the three major forest categories are compared in Table 4. The relative abundance and relative biomass were greater on mature conifer habitats, whereas species diversity, richness, and evenness were all lower on mature conifer habitats than on the other two major forest categories. The early successional stage mammal communities differed from the mature hardwood and mixed forests only in having a higher species richness. The dominance of *Clethrionomys gapperi* and the absence of most other species in the mature conifer forests was the critical feature in these differences.

Monthey and Soutiere (1985) found no difference in total small mammal abundance between early successional stages and later forest stages. Kirkland

TABLE 4. Analysis of small mammal community structure by major forest category. Methods of calculating abundance, richness, diversity and evenness are explained in the text.

Species	Early successional stage habitats 1-7	Mature conifer habitats 8-10	Mature mixed and hardwood habitats 11-14
<i>Sorex cinereus</i>	15	2	2
<i>Sorex palustris</i>	3		
<i>Sorex fumeus</i>		1	
<i>Blarina brevicauda</i>	6		9
<i>Peromyscus maniculatus</i>	59	7	19
<i>Clethrionomys gapperi</i>	63	55	21
<i>Microtus pennsylvanicus</i>	16		
<i>Microtus chrotorrhinus</i>	3		3
<i>Zapus hudsonius</i>	8		
<i>Napeozapus insignis</i>	1		4
Total caught	174	65	58
Total trap nights	3330	1080	1080
Relative abundance	5.23	6.02	5.37
Species richness	9	4	6
Species diversity	1.60	0.56	1.48
Evenness	0.73	0.40	0.83
Total biomass	3311.9	1404.8	1165.2
Relative biomass	99.5	130.1	107.1

(1977) found that small mammal communities in West Virginia, within five years after clearcutting on both coniferous and deciduous forests, had increased diversity indices and evenness. However, species richness on deciduous forests was not increased.

Species Habitat Distribution and Abundance

For each species the number of habitats of occurrence, niche breadth and relative abundance are given in Table 5. *C. gapperi* was the most abundant species (46.6% of the total) and was most widely distributed (13 of the 14 habitat types). *P. maniculatus* ranked second in both regards. Three more species, *S. cinereus*, *B. brevicauda*, and *M. pennsylvanicus*, had moderate abundance. The remaining five species had low numbers and narrow habitat distributions. The niche breadth, reflecting both numbers of habitats used and evenness of abundance in those habitats, was highest in *C. gapperi*, followed by high values in *S. cinereus*, *B. brevicauda*, and *P. maniculatus*. The other six species had narrow niche breadths.

Sorex cinereus was the most common and widely distributed of the three species of this genus collected in this study. It was absent only from the Black Spruce

TABLE 5. Habitat distribution and abundance of the 10 species of mammals on the 14 habitat types. Relative abundance is in number per 100 TN.

Species	Number of habitats	Niche breadth	Relative abundance
<i>Sorex cinereus</i>	9	7.37	0.356
<i>Sorex fumeus</i>	1	1.00	0.018
<i>Sorex palustris</i>	2	1.80	0.055
<i>Blarina brevicauda</i>	9	6.82	0.273
<i>Peromyscus maniculatus</i>	12	4.27	1.530
<i>Clethrionomys gapperi</i>	13	8.33	2.495
<i>Microtus pennsylvanicus</i>	3	2.13	0.291
<i>Microtus chrotorrhinus</i>	2	2.00	0.109
<i>Zapus hudsonius</i>	3	1.68	0.146
<i>Napeozapus insignis</i>	3	2.27	0.091
Total sample	14		5.355

habitat and from both habitats in the White Mountains. *S. fumeus* (Smoky Shrew) was rare. *S. palustris* (American Water Shrew) also was rare; three specimens were collected along small streams in two habitats which had been burned. The sampling methods, using commercial snap traps, may have attributed to the low catches of shrews or the short sampling period may have coincided with low population levels of shrews. While sampling with snap traps in northwestern Maine, Richens (1974) found higher levels of shrews than those of this study. Richens found *S. fumeus* to be more abundant than reported here and he also collected several *Sorex hoyi* (Pigmy Shrew). Monthey and Soutiere (1985), who collected in the spruce-fir region of northwestern Maine, found more *S. hoyi*, *S. fumeus*, and one *S. dispar* (Long-tailed Shrew) during their extensive sampling totalling 60,279 TN.

Blarina brevicauda was as widely distributed as *S. cinereus* in this study and coexisted with that species in six of the nine habitats where it was found. *P. maniculatus* was absent from only two habitat types: the Black Spruce and the mature mixed forest of the Chesuncook area. The latter site had a low sampling effort. *C. gapperi* was absent from one habitat, the natural burn at Baxter State Park. Its absence there might have been due to the high numbers of *P. maniculatus*, since it has been observed that these two species may be competitors (Grant 1970).

M. pennsylvanicus was found in the two habitats where trees had been defoliated by Spruce Budworm and in the spruce-fir habitat which had been clearcut and burned. Both *Zapus* and *Napeozapus* were low in abundance. *Z. hudsonius* (Meadow Jumping Mouse)

was found in three of the early successional stage habitats. One *N. insignis* (Woodland Jumping Mouse) was taken in one early successional stage habitat and the others in mature mixed and hardwood habitats.

The presence of *M. chrotorrhinus* in two forest habitats at low elevation in Baxter State Park is noteworthy. Previously, this species had been recorded from six localities in Maine: five mountain areas over 1000 m above sea level and one location about 500 m altitude in moss-covered Krummholz (Chodrow and Martin 1978). I captured three specimens of this species on 13 July in a defoliated spruce-fir habitat at 400 m altitude, along with abundant *C. gapperi*, *M. pennsylvanicus*, and *P. maniculatus*. Individuals of all three of the microtine species were captured at one trapping station where a thick moss carpet covered the ground and the forb and shrub layers were dense. These three *M. chrotorrhinus* were pregnant females (4, 4, and 3 embryos). Two of them were lactating, indicating that they had already given birth to one litter. About 2 km away three male juvenile *M. chrotorrhinus* were captured on the same day in the mature Sugar Maple habitat at 410 m altitude. These occurrences of this species support the contention of Kirkland and Knipe (1979) and of Buech et al. (1977) from records in New York and Minnesota, respectively, that the species is widely distributed in low elevation mature northern hardwood habitat as well as in high elevation boreal forests with rocky, moist substrate.

Trophic Level Responses

The composition by trophic levels of small mammal communities on the three major forest categories is given in Table 6 by numbers and biomass. The early successional stages and the mature mixed and hardwood forests were similar in the percentages of the three trophic levels they contain. In the mature conifer forests insectivores and granivore-omnivores were lower, while grazer-omnivores were higher than in the other two forest categories. Similar comparisons among the three forest categories were found in the biomass proportions of the three trophic levels. *C. gapperi* constituted the entire grazer-omnivore component in the mature conifer forest habitats. In one of these habitats, the Black Spruce, where there was almost no ground vegetation of grass, forbs, or low shrubs, it is likely that this species ate fungi and moss. Kirkland (1978a, b) found that insectivores remained unaffected, granivore-omnivores tended to decline, and grazers increased after clearcutting of mixed hardwood in West Virginia and northern Pennsylvania. On his study sites it was *C. gapperi* which was responsible for the increase in grazer-omnivore numbers, whereas I found no such response

TABLE 6. Composition of small mammal communities by trophic structure in the major forest categories of northern Maine. Percentage of numbers and of biomass of each trophic level within the forest categories with the number of animals in parentheses.

Forest Category	Early successional stage	Mature conifer	Mature mixed and hardwood
Trophic Level			
Insectivore			
Number	13.8% (24)	4.6% (3)	19.0% (11)
Biomass	6.1%	1.2%	14.7%
Grazer-Omnivore			
Number	47.1% (82)	84.6% (55)	41.4% (24)
Biomass	60.8%	89.6%	42.7%
Granivore-Omnivore			
Number	39.1% (68)	10.8% (7)	39.7% (23)
Biomass	33.0%	9.1%	43.1%

to clearcutting on the part of this species.

In summary, the relative abundance, species richness, and diversity of small mammals were moderate to high at the sites where the litter, ground and shrub layers of vegetation were well developed. The abundance, richness, and diversity of the small mammal communities tended to be low where the ground and shrub layers were sparse, as on a cutover area treated with herbicide or under a mature forest canopy. Clearcutting probably affects small mammal populations mainly through its alteration of the shrub and ground vegetation, rather than through removal of the tree canopy.

Many variables tend to affect small mammal populations and may account for the wide variation of reported results on the impact of forest management practices on these populations. Some of these variables are the collecting method used, the time of year, the precise nature of the forest manipulation as well as the changes it causes in soil exposure, litter structure and moisture content, characteristics of ground, forb, and shrub layers of vegetation, and proximity to other habitats which may serve as sources of immigration of small mammals. There are also the variables of the mammal populations themselves, such as density-dependent fluctuations of numbers and reproductive productivity and behavioral interactions within and among species.

The results of this and other studies clearly show that no forest management practice in itself has a detrimental effect on small mammals in general, but that every practice may cause changes in some aspects of the mammal community structure and composi-

tion. Specific ecological and physiological tolerances and requirements must shape each species' response to changes caused by forest management. Interactions among species, either of a competitive or positive nature, may also influence the way small mammal communities respond to changes in their forest habitats.

Acknowledgments

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Literature Cited

- Buech, R. R., R. M. Timm, and K. Siderits. 1977. A second population of Rock Voles, *Microtus chrotorrhinus*, in Minnesota with comments on habitat. *Canadian Field-Naturalist* 91: 413-414.
- Chodrow, R. F., and R. Martin. 1978. The yellow-nosed vole in Maine and its relevance to The Critical Areas Program. Maine State Planning Office. Planning Report No. 57: 1-20.
- Grant, P. R. 1970. Experimental studies of competitive interaction in a two-species system. II. The behavior of *Microtus*, *Peromyscus*, and *Clethrionomys* species. *Animal Behaviour* 18: 411-426.
- Kirkland, G. L., Jr. 1977. Responses of small mammals to clearcutting of northern Appalachian forests. *Journal of Mammalogy* 58: 600-609.
- Kirkland, G. L., Jr. 1978a. Initial responses of small mammals to clearcutting of Pennsylvania hardwood forests. *Pennsylvania Academy of Science* 52: 21-23.
- Kirkland, G. L., Jr. 1978b. Population and community responses of small mammals to 2, 4, 5-T. USDA Forest Service Research Note. PNW-314, Portland, Oregon. 7 pp.
- Kirkland, G. L., Jr., and C. M. Knipe. 1979. The Rock Vole (*Microtus chrotorrhinus*) as a transition zone species. *Canadian Field-Naturalist* 93: 319-321.
- Krebs, C. J., and I. Wingate. 1976. Small mammal communities of the Klane Region, Yukon Territory. *Canadian Field-Naturalist* 90: 379-389.
- Krull, J. N. 1970. Small mammal populations in cut and uncut northern hardwood forests. *New York Fish and Game Journal* 17: 128-130.
- Lovejoy, D. A. 1975. The effect of logging on small mammal populations in New England northern hardwoods. University of Connecticut Occasional Papers (Biological Science Series) 2: 269-291.
- Lull, H. W. 1968. A forest atlas of the northeast. Northeastern Forest Experimental Station Forest Service, U.S.D.A., Upper Darby, Pennsylvania.
- Martell, A. M. 1984. Changes in small mammal communi-

- ties after fire in north central Ontario. *Canadian Field-Naturalist* 98: 223-226.
- Martell, A. M., and A. Radvanyi.** 1977. Changes in small mammal populations after clearcutting of northern Ontario Black Spruce. *Canadian Field-Naturalist* 91: 41-46.
- Monthey, R. W., and G. C. Soutiere.** 1985. Responses of small mammals to forest harvesting in northern Maine. *Canadian Field-Naturalist* 99: 13-18.
- Oliveri, S. F., and N. C. Famous.** 1983. A comparison of bird populations in moribund and healthy spruce-fir stands in Maine. *Environmental Monitoring Reports*. Maine Forest Service, Augusta, Maine 1983: 94-128.
- Pielou, E. C.** 1975. *Ecological diversity*. J. Wiley & Sons, New York. 165 pp.
- Richens, V. B.** 1974. Numbers and habitat affinities of small mammals in northwestern Maine. *Canadian Field-Naturalist* 88: 191-196.
- Society of American Foresters, Maine Chapter.** 1974. Forest-practice and standards. *Maine Forest Review* 7: 1-21.
- Soutiere, E. C.** 1979. Effects of timber harvesting on marten in Maine. *Journal of Wildlife Management* 43: 850-860.
- Sullivan, T. P.** 1980. Comparative demography of *Peromyscus maniculatus* and *Microtus oregoni* populations after logging and burning of coastal forest habitats. *Canadian Journal of Zoology* 58: 2252-2259.
- Trask, H. W.** 1982. Fate of carbaryl in Maine spruce-fir forests. (A literature survey.) Maine Department of Conservation, Augusta, Maine. 50 pp.

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Seabirds in the Cape Dyer–Reid Bay Area of Cumberland Peninsula, Baffin Island, Northwest Territories

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Gaston, A. J., and S. A. Smith. 1987. Seabirds in the Cape Dyer–Reid Bay area of Cumberland Peninsula, Baffin Island, Northwest Territories. *Canadian Field-Naturalist* 101(1): 49–55.

We visited the large, multi-species seabird colony situated southeast of Reid Bay 15–30 July 1985 and estimated that 133 000 pairs of Thick-billed Murres (*Uria lomvia*), 12 000 – 20 000 Northern Fulmars (*Fulmarus glacialis*) and 1200 – 1300 pairs of Black-legged Kittiwakes (*Rissa tridactyla*) breed in the area. This is the only colony in the eastern Canadian Arctic, apart from Prince Leopold Island, where all these species nest intermingled. In the absence of any close geographic feature after which to name the colony we propose that it be called “The Minarets”, emphasizing the extraordinary erosion features on which many of the birds breed.

Key Words: The Minarets, Thick-billed Murre, *Uria lomvia*, Northern Fulmar, *Fulmarus glacialis*, Black-legged Kittiwake, *Rissa tridactyla*, Northwest Territories.

The existence of a large seabird colony on the eastern tip of the Cumberland Peninsula, between Cape Dyer and Cape Searle, was reported by Boas (1884–85) who mapped the position under the name “Agpan” [Wynne-Edwards (1952a) and Watson (1957)]. The exact position (66°55'N, 61°45'W) was observed in 1973 during aerial surveys carried out by D. N. Nettleship and R. C. Elliott and subsequently published by Nettleship and Smith (1975). The size and species composition was estimated at 200 000 pairs of Thick-billed Murres, *Uria lomvia*, and 10 000 pairs of Northern Fulmars, *Fulmarus glacialis* (Nettleship and Smith 1975; Brown et al. 1975), but these figures have been regarded previously as indicating only orders of magnitude.

Although the colony was visited periodically by local Inuit, particularly when the settlement at Padloping Island was in existence (K. Harper, personal communication), there is no published account of the colony by investigators on the ground. We visited the colony between 15 and 30 July 1985 to carry out an inventory of breeding seabirds in the area and this paper provides a general description of the seabird populations and an account of our census work.

Study Area

All of the Thick-billed Murres and the majority of the Northern Fulmars breed on east-facing cliffs which rise to a height of about 800 m on a headland separating two un-named fjords (locally called *Ugak* (Cod) Fjord and *Akpa* (Murre) Bay).

A small number of fulmars also breed near the cliff tops on the south side of Ugak Fjord. Black-legged Kittiwakes, *Rissa tridactyla*, breed on a small area of cliffs at the base of the murre colony.

Two cliffs on which the Thick-billed Murres breed

are composed of basalt which is eroded into irregular pinnacles and knife-edge spurs separated by deep gullies (Figure 2). To the north a huge portion of the headland has collapsed to form a basal scree of gigantic boulders (Figure 3) flanked by shear rock walls. The southern boundary of the murre colony is formed by a cirque about 1.5 km across.

Most of the murres breed on the pinnacles and knife-edge spurs which are completely inaccessible from the land, although they can be readily viewed from the edge of the upper plateau (Figure 4). They are confined to the upper half of the cliff except for a small group breeding close to the sea among the Black-legged Kittiwakes. Some murres also breed on two towers flanking the valley to the north of the main colony, in which our camp was situated (northeast and northwest towers, Figure 2).

Northern Fulmars are scattered throughout the area occupied by murres, particularly near the top, and at all elevations on the north and northeast walls (Figure 2). They also breed on some areas of the cirque, and around the southeast ridge, mainly near the top. Glaucous Gulls, *Larus hyperboreus*, breed in small groups or singly throughout the colony and we estimated about 70 pairs. Two small colonies of Iceland Gulls, *Larus glaucoides*, also occur: one at the foot of the southeast ridge (12 pairs) and the other near the head of Ugak Fjord (15 pairs). A few Black Guillemots, *Cephus grylle*, breed in rock crevices among boulders on nearby islets, on cliffs on the headland immediately to the south of the main colony, and in adjacent fjords.

Methods

We counted the murres on all parts of the colony that could be viewed from the land. To do this we counted groups of 100 murres one by one until we felt

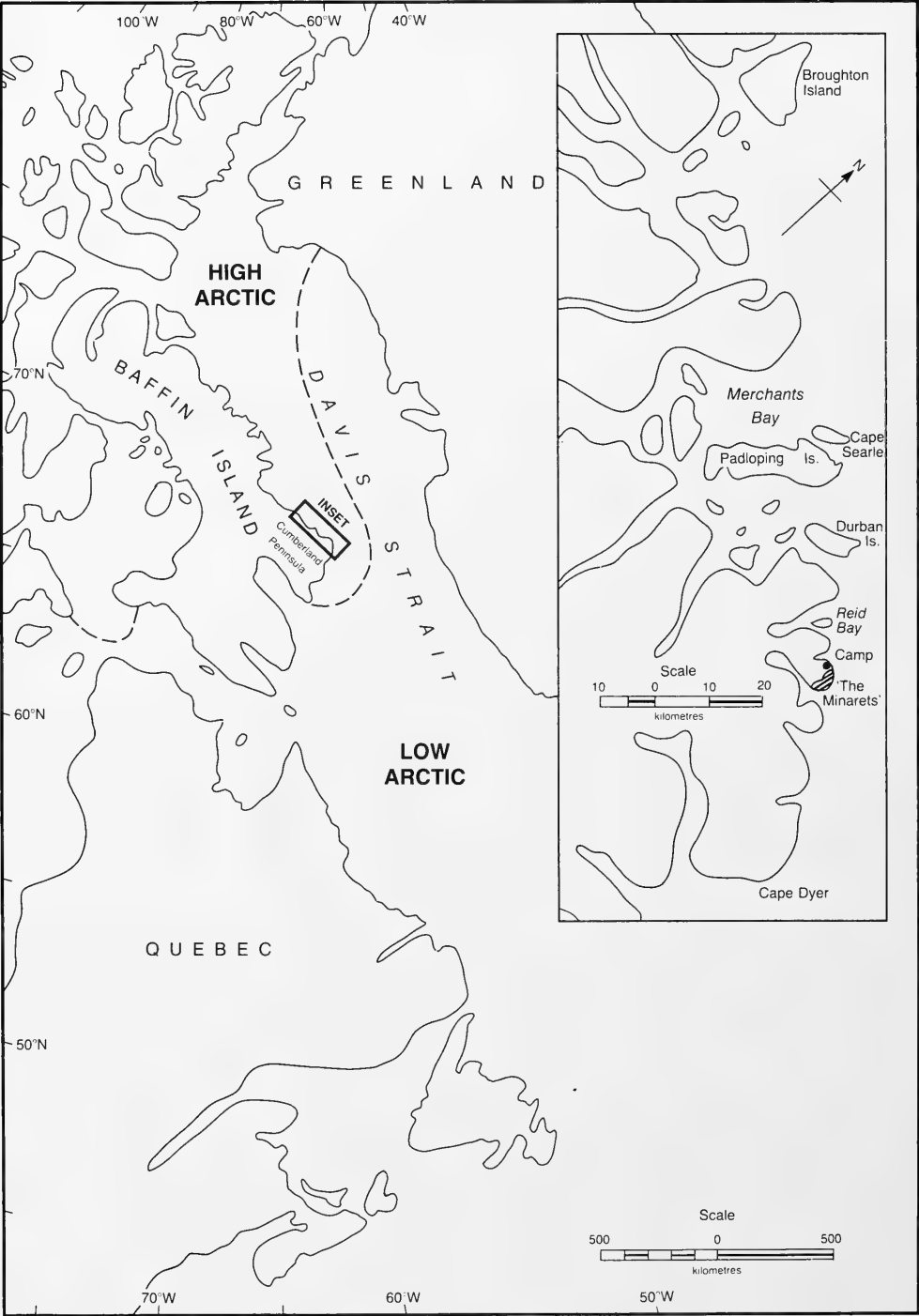


FIGURE 1. Map showing the position of localities mentioned.

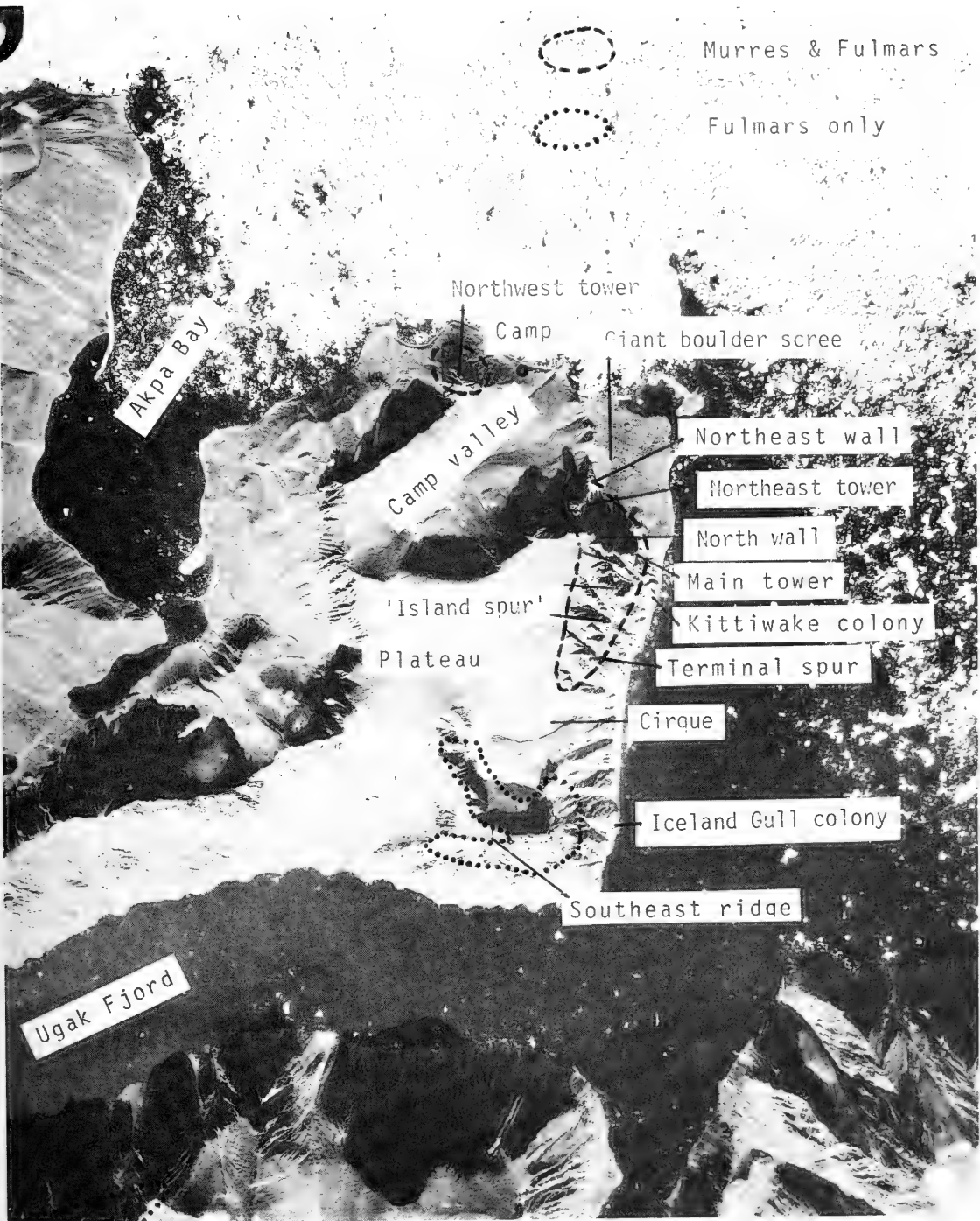


FIGURE 2. Aerial photograph showing details of the colony area and places which we named in order to simplify our survey notes [Not official geographical names.]

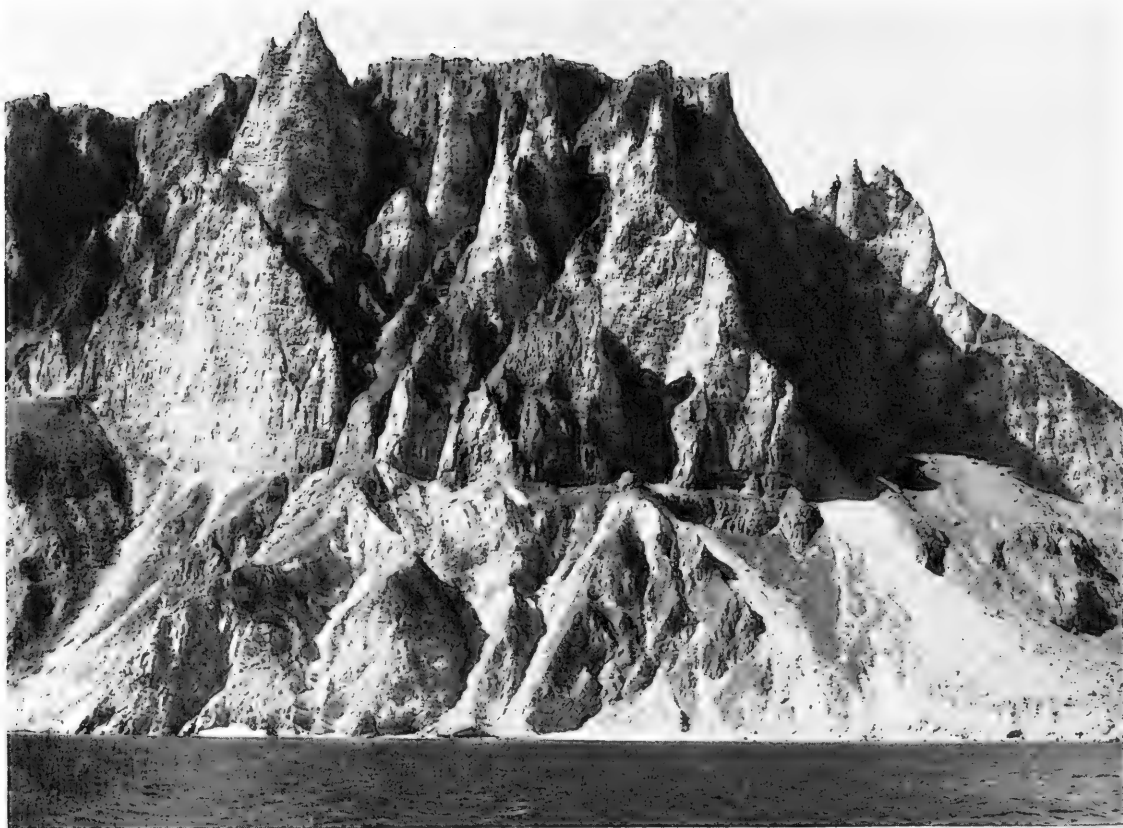


FIGURE 3. The southeast tip of the colony headland viewed from the south.

confident that we could estimate by blocks of 100. We then divided the visible area into discrete blocks, using natural features, and counted by hundreds. We checked our accuracy by repeating counts using individual birds and found our counts by hundreds to be accurate to within 10% where more than 1000 birds were counted. We found no systematic biases in our counts by hundreds when compared with counts of individual birds. All counts were made between 1000 and 1700 h EDT.

Birds in areas that were not visible from the land could not be counted because it was impossible to observe the cliffs satisfactorily through binoculars from our small inflatable boat. For these areas we made rough estimates by comparing them to adjacent areas which had been counted from the land. There was no way to assess the accuracy of this procedure. Details of our counts and estimates are given in Table 1.

Results and Discussion

We counted 149 465 Thick-billed Murres from the land and estimated a further 30 000 from the sea. Assuming that some birds were not visible either from land or sea and that a few were overlooked under overhangs, or behind other birds, 190 000 is our best estimate for the number of murres present during the day at the time of our visit. Our counts were probably accurate to within $\pm 15\%$, but if the estimates from the sea were only accurate to $\pm 50\%$, then the overall accuracy is probably $\pm 25\%$.

During the period of the census most birds were either in the late stages of incubation or were brooding young chicks. The corresponding ratio of numbers of birds present to numbers of breeding pairs for Thick-billed Murres at this stage of the breeding cycle is about 0.7 (Gaston and Nettleship 1981); this suggests a total breeding population of approximately 133 000 pairs with likely limits of 100 000 – 166 000 pairs.



FIGURE 4. One of the main breeding concentrations, seen from the adjacent cliff top.

We counted Northern Fulmars on the north and northeast walls and on 'island spur' on 23, 24 and 25 July and estimated other areas by extrapolation. Many of the Northern Fulmars observed were extremely dark in color, looking similar in shade to Sooty Shearwaters, *Puffinus griseus* (equivalent to the DD phase of Van Franeker and Wattel (1982)).

These birds were very difficult to pick out against the blackish basalt of the cliffs. Furthermore, many breeding sites were in crevices or under overhangs which made them hard to see. Consequently, we believe that our counts considerably underestimated the number of fulmars present.

Based on our counts, we estimated that 10 150

TABLE 1. Counts and estimates of Thick-billed Murres present on the colony.

Area	Date	Number	Method
Northwest tower	22 July	6 800	Count
Northeast tower	23, 26 July	11 860	Count
Main tower to terminal ridge	23, 24, 27 July	123 255	Count
Main tower to terminal ridge	29 July	30 000	Estimate from sea
Lower (kittiwake) cliffs	29 July	1 400	Count
Other small areas	23 July	6 150	Count
Total		179 465	

TABLE 2. Distribution of Northern Fulmars and minimum estimates of numbers present on 22 to 24 July.

Area	Estimate
North wall	1 250
Northeast wall and tower	1 150
Northwest tower	500
Rest of murre colony	4 000
Cirque	750
Southeast ridge	1 750
Far side of "Ugak Fjord"	750
Total	10 150

Northern Fulmars were present in the colony (Table 2), but we feel that this must be an underestimate because the dark phase birds are so hard to see. We consider that the true figure is between 12 000 and 20 000 birds. We do not wish to speculate on the number of breeding pairs represented by this many individuals. Most breeding fulmars were brooding small chicks at the time of the count.

To estimate Black-legged Kittiwakes numbers, we counted nests with at least one adult bird in attendance, including only those nests with a well-formed cup. The count was made on 16 July from the boat. Most nests contained small chicks on that date. Repeat counts by both observers yielded totals of 1200–1300 nests.

The colony site lies close to the boundary of high and low arctic waters in Davis Strait (Salomonsen 1972; Brown et al. 1975). Although it falls on the high arctic side of the boundary, some birds from the colony almost certainly forage in low arctic waters in the centre of Davis Strait because large flocks were seen flying in towards the colony from the east. The numbers of Thick-billed Murres breeding are similar to those at other major colonies in the high arctic of

eastern Canada (Brown et al. 1975; Nettleship and Evans 1985). Among major seabird colonies of the eastern arctic it is unusual in that it is the only one other than Prince Leopold Island where Thick-billed Murres, Northern Fulmars and Black-legged Kittiwakes nest intermingled. The importance of the colony was recognized by the International Biological Programme which proposed that it be specially protected (Nettleship and Smith 1975). The size and diversity of the seabird population of the area, along with the threat posed by current plans for the marine transport of hydrocarbons through Davis Strait (FEARO 1984), have prompted the Canadian Wildlife Service to designate the colony area, along with the nearby Northern Fulmar colony at Cape Searle (Wynne-Edwards 1952b; Nettleship and Smith 1975), as a Migratory Bird Sanctuary under the combined title of "East Baffin Seabird Sanctuary".

The colony has been previously referred to as 'Reid Bay' (Nettleship and Smith 1975; Brown et al. 1975). This name has the virtue of invoking the nearest feature included on the 1:250 000 topographic map, but it is somewhat misleading because the colony is several kilometers from that bay. Consequently, we sought a suitable name for the actual colony site. The local Inuit name is "Agpait" which means simply "the place of the murres". As this name is normally applied by Inuit to any murre colony it does not seem suitable as a name for a specific colony. In view of the spectacular towers and pinnacles on which most of the murres nest, which are grander in scale than those of any other Canadian murre colony, we propose that the colony site be named "The Minarets", resembling as it does the cupolas and minarets of a mosque.

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Coast Guard, the Northern Land-use Inventory Survey of Lands Directorate, Environment Canada and the staff of Cape Dyer D.E.W. line station for assistance with logistics. Andy Thériault of Department of Indian and Northern Affairs allowed us to make use of the Ikaluit Laboratory in Frobisher Bay and Lyn Cousins and Bobby Christensen maintained radio contact with us. In Broughton Island we were assisted by the Renewable Resources Officer, Theo Ikummaq, and received information and assistance from many others. We also thank David Nettleship and Hugh Boyd for commenting on the manuscript.

Literature Cited

- Boas, F.** 1884-85. The Central Eskimo. Smithsonian Institution. Sixth Annual Report of the Bureau of Ethnology, Washington, D.C.
- Brown, R. G. B., D. N. Nettleship, P. Germain, C. E. Tull, and T. Davis.** 1975. Atlas of eastern Canadian seabirds. Canadian Wildlife Service, Ottawa. 220 pp.
- FEARO.** 1984. Beaufort Sea hydrocarbon production and transportation: final report of the Environmental Assessment Panel. Federal Environmental Assessment and Review Office, No. 25. 146 pp.
- Gaston, A. J., and D. N. Nettleship.** 1981. The Thick-billed Murres of Prince Leopold Island. Canadian Wildlife Service Monograph Series No. 6. 350 pp.
- Nettleship, D. N., and P. G. H. Evans.** 1985. Distribution and status of the Atlantic Alcidae. Pp. 53-154 in *The Atlantic Alcidae. Edited by D. N. Nettleship and T. R. Birkhead.* Academic Press, Orlando and London.
- Nettleship, D. N., and P. A. Smith.** 1975. Ecological sites in northern Canada. Canadian Committee for the International Biological Programme, Conservation Terrestrial — Panel 9, Ottawa. 329 pp.
- Salomonsen, F.** 1972. Zoogeographical and ecological problems in arctic birds. Proceedings of the International Ornithological Congress 15: 25-77.
- Van Franeker, J. A., and J. Wattel.** 1982. Geographical variation of the Fulmar *Fulmarus glacialis* in the North Atlantic. *Ardea* 70: 31-44.
- Watson, A.** 1957. Birds in Cumberland Peninsula, Baffin Island. *Canadian Field-Naturalist* 71: 87-109.
- Wynne-Edwards, V. C.** 1952a. Zoology of the Baird expedition (1950). I. The birds observed in central and southeast Baffin Island. *Auk* 69: 353-391.
- Wynne-Edwards, V. C.** 1952b. The fulmars of Cape Searle. *Arctic* 5: 105-117.

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Food Habits of Bull Char, *Salvelinus confluentus*, and Rainbow Trout, *Salmo gairdneri*, Coexisting in a Foothills Stream in Northern Alberta

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Boag, T. D. 1987. Food habits of Bull Char, *Salvelinus confluentus*, and Rainbow Trout, *Salmo gairdneri*, coexisting in a foothills stream in northern Alberta. *Canadian Field-Naturalist* 101(1): 56-62.

Food habits of Bull Char and Rainbow Trout, coexisting in the Muskeg River system in western Alberta, were based on 50 stomach samples of the former and 63 of the latter. Fish were sampled by angling during the summer of 1984. Bull Char was more piscivorous than Rainbow Trout in the lower reaches of this drainage but had essentially the same diet in the upper reaches where ephemeropterans, plecopterans, trichopterans, and coleopterans were the heavily used forms. The volume of stomach contents increased over the course of the summer in both species, suggesting little competition for food.

Key Words: Food habits, Bull Char, *Salvelinus confluentus*, Rainbow Trout, *Salmo gairdneri*, Alberta.

The Bull Char (*Salvelinus confluentus*), a freshwater char, is native to western North America. In Alberta, it is indigenous to the east slope streams of the Rocky Mountains, extending from the South Saskatchewan drainage in the south to the Peace in the north (Paetz and Nelson 1970). Little information exists on either the biology or ecology of this char in these east slope streams, although considerable information is available on the related Dolly Varden (*Salvelinus malma*), a char of the coastal regions of western North America (Armstrong and Morton 1969); before 1978, the Dolly Varden was generally considered conspecific with Bull Char (Cavender 1978). Many populations of this species in Alberta have suffered a dramatic decrease in numbers in recent years (Kvisle 1983; Westaway 1983; Zemanek 1983).

Allen [1980. Life history of the Dolly Varden Char (*Salvelinus malma*) in the Upper Clearwater River, Alberta. Report, Alberta Division of Fish and Wildlife, Edmonton] speculated that Rainbow Trout (*Salmo gairdneri*) do not compete with Bull Char for living space, and by implication, for food. Furthermore, studies of food habits of the related Dolly Varden suggest that char in general are highly piscivorous and therefore may not use the same food base as the basically insectivorous trout (*Salmo* spp.) (Kroquis and Krokhin 1948; Lagler and Wright 1962; Cavender 1978). However, such documentation is missing from the east slopes range of *S. confluentus*. This study attempts to close these gaps by addressing the following questions: 1) what do Bull Char prey upon during the May-August season (main growth period)? 2) how does this diet compare with that of Rainbow Trout from the same drainage? 3) does the

diet change over the course of the summer in either species? 4) does the presence of a system of beaver dams produce a change in the food habits of these salmonids resident above and below the obstruction?

Methods and Materials

The Muskeg River drainage in Alberta (Figure 1), the site chosen for this study, is reported to have a healthy population of Bull Char and several other species of fish (Haugen, 1965. Muskeg River Drainage System. Memorandum, Alberta Division of Fish and Wildlife, Edmonton). Rainbow Trout have been introduced into the drainage since 1970, specifically into the Pierre Grey's Lakes. From these lakes Rainbow Trout have dispersed directly into the Muskeg River (Figure 1), which was reported not to support this species before 1970 (Haugen, see above).

Samples of fish were taken in 1984 from two sections of this drainage, above and below a complex of beaver (*Castor canadensis*) dams on the Muskeg river (Point A—Figure 1). The downstream sample included fish from 1) the Muskeg River below the beaver dam to a point where the river crosses Highway 40 North, 2) from Lone Teepee Creek, a tributary of the Muskeg River, and 3) from Burleigh Creek, a tributary of Lone Teepee Creek (Figure 1). The upstream sample included fish from the Muskeg River above the beaver dams to the confluence with A la Pêche Creek itself (Figure 1).

Bull Char and Rainbow Trout were sampled by angling. Artificial flies on large barbless hooks (sizes 2-8) were used. Sections of stream presumed to contain fish were first angled with a fish-imitating fly ("bucktail") and then with a fly imitating a large stonefly nymph. The sequence of use of these lures was

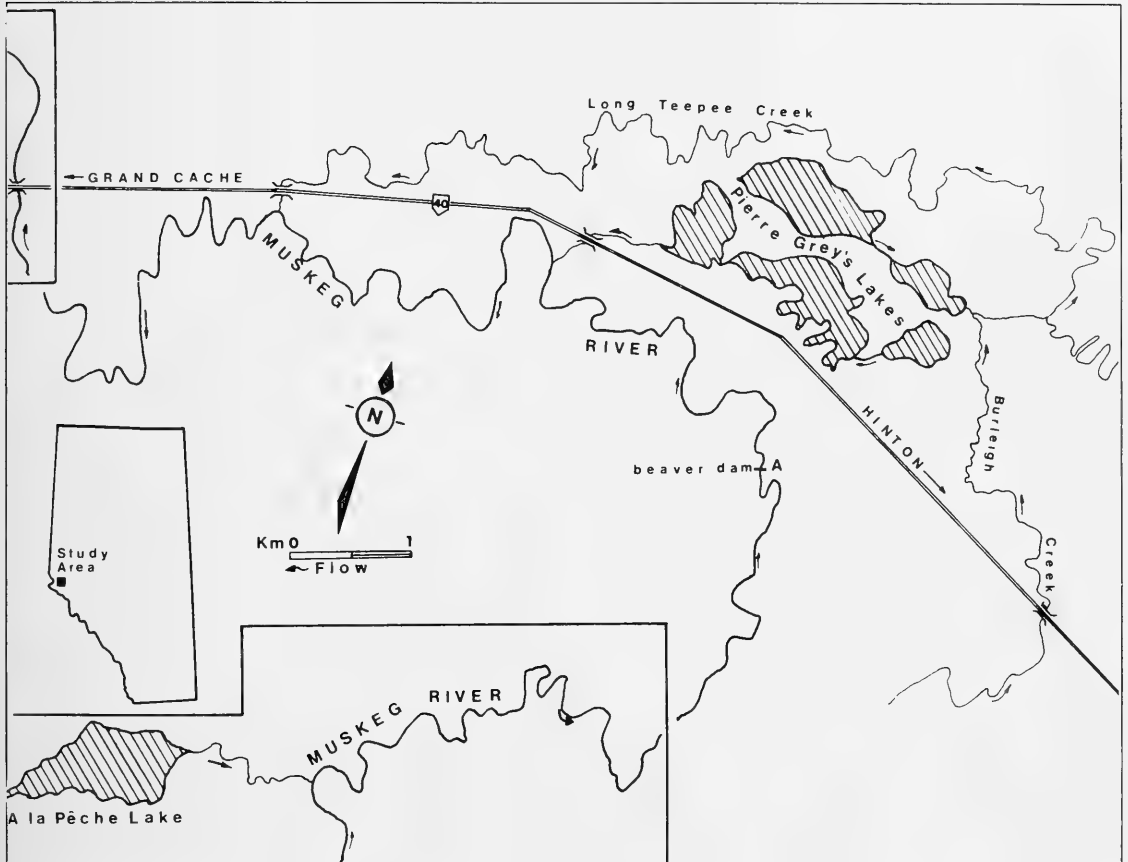


FIGURE 1. Sections of the Muskeg River and its tributaries from which samples of Rainbow Trout and Bull Char were angled during the summer of 1984.

based on the premise that this method would select first for piscivorous forms—Bull Char and possibly larger Rainbow Trout. Sampling effort was maintained at a reasonably constant level along stretches of the streams by angling for 20 to 30 minutes after the last fish taken at a given site had been released. The number of fish so taken varied between 0 and 18. Once an area had been sampled successfully, a minimum of three days was allowed to pass before the area was resampled.

The summer season was subdivided into two equal sampling periods: 1) May-June, and 2) July-August. An adequate sample size could not be obtained on a monthly basis because high water conditions prevented the collection of a reasonable sample in May. During the May-June period, most samples came from Lone Teepee and Burleigh creeks as the

Muskeg River was high and turbid, and hence unsuitable for angling. In the July-August period, samples were taken from the Muskeg River and its tributaries, including A la Pêche Creek.

Fish were anaesthetized with MS222 (tricaine methane sulphonate) and fork length and weight were recorded, scales were removed to determine age, stomach contents were retrieved, and the time and location of capture noted. To collect stomach contents, a flushing system similar to that employed by Meehan and Miller (1978) was used. This involved injecting water into the stomach with the aid of a 20 ml syringe to which was attached a 30 cm length of plastic tubing. The fish were held in an apparatus similar to that described by Crossman and Hamilton (1978). This apparatus consisted of a wooden box with a V-shaped bottom into which the anaesthetized fish was

placed. To flush the stomach, the jaws were held open using a nylon stocking and the plastic tubing inserted down the esophagus. Water was injected from the syringe and the stomach contents were flushed onto a screen at one end of the box.

The stomachs of large Bull Char (over 600 g) were filled with water, then pressure was placed manually from the posterior to anterior portion of the abdomen. This enabled material such as partially digested fish remains to be "force-flushed" successfully. Once their stomachs had been flushed with water, fish were returned to the location where they were caught. Stomach contents were placed in plastic vials and fixed in 95% ethanol.

Volume and frequency of occurrence were used in examining stomach contents (reviewed by Hynes 1956; Hyslop 1980). Volumes of invertebrates were determined by water displacement in a graduated cylinder. For large individuals (e.g. stoneflies) a single specimen was used, but for smaller ones (e.g. blackfly larvae) 20 or more individuals were placed in the cylinder and the volume displaced per individual was calculated.

Age of fish sampled was determined from scales that had been subjected to trypsin (Sosiak and Griffiths, 1983. Bow River trout population studies, fall 1980-82. Report, Alberta Division of Fish and Wildlife, Calgary) to enhance the visibility of the annuli. To determine the importance of a certain food type in a fish's diet over a period of time, the "index of relative importance" (IRI) (Pinkas et al. 1971; Prince 1975) was used. This takes into account the number (N), volume (V) and frequency of occurrence (F) of the food type in the diet— $IRI = (\%N + \%V)(\%F)$.

Results

The age distribution of the Bull Char and Rainbow Trout sampled (Figure 2) suggests that younger fish were either poorly represented in the population or, more likely, less vulnerable to the sampling procedure used. A comparison of length/weight relationships in the two species suggests that their growth rates were similar (Figure 2). In general, Bull Char from the Muskeg River appeared to be larger than Bull Char of equivalent age in the Clearwater River system in southwestern Alberta (Table 1), possibly reflecting a richer food base in the smaller and slower Muskeg River than in the larger and faster Clearwater River.

Of 50 Bull Char captured, prey items were obtained from the stomachs of only 33 (66%), whereas of 63 Rainbow Trout sampled, stomach contents were obtained from 62 (98%).

A comparison of the diets of the two species in the lower reaches of the Muskeg River (below the beaver dams) suggests that Bull Char are much more

piscivorous than Rainbow Trout (Figure 3). Overall, fish and Rainbow Trout eggs composed 23.3% by volume of the diet of Bull Char but only 0.04% of the diet of Rainbow Trout; in the latter species only fish eggs were recorded. Rainbow Trout appeared to feed primarily on aquatic insects (99.96% of the diet), particularly mayfly nymphs and adults. This compares with an aquatic insect component of 76.7% in the diet of Bull Char. Stonefly nymphs and adults (Plecoptera: Nemouridae), mayfly nymphs and adults (Ephemeroptera: Baetidae, Hexageniidae), caddisfly larvae and adults (Trichoptera: Leptoceridae, Limnephilidae, Brachycentridae, Hydropsychidae) and fly larvae (Diptera: Chironomidae, Simuliidae) were the most important prey items (Table 2).

A change in the relative composition of the diet of both Rainbow Trout and Bull Char over the course of the summer of 1984 involved a many-fold increase in the use of mayflies (Figure 3). Unlike the diet of Bull Char, the diet of Rainbow Trout did not differ markedly above and below the dam (fish were not sampled above the dam before the July-August sampling period). Below the dam, 92% (11/12) of the Bull Char stomachs sampled contained fish or fish remains (Rainbow Trout in the 1+, 2+ and 3+ year classes) (Table 2), whereas above the dam, none of the 21 Bull Char stomachs with food contained fish (Figure 3). These food habits are reflected in the relative angling success with fish- and insect-imitating lures (Table 3). Upstream from the dam, 67% of Bull Char were captured on insect-imitating lures, 33% on fish-imitating lures. The opposite occurred downstream, where 8% of Bull Char were captured on insect-imitating lures, and 92% on fish-imitating lures.

As the summer progressed, a marked increase in the mean volume of individual stomachs of both Rainbow Trout and Bull Char was recorded (Figure 3). This probably reflects the increased availability of prey items to salmonids in these streams during the latter half of the sampling period.

Based on the condition of the prey items, it appeared that Bull Char, using fish prey, were feeding in "pulses" (invertebrate material was usually regurgitated first and was either still alive or in a fresh condition, whereas fish remains were always almost completely digested). Having taken a fish, Bull Char spend a variable amount of time digesting it, about 12 hours according to Armstrong and Blackett (1966), before initiating another feeding "pulse". The stomach contents suggest that they may supplement, opportunistically, the partially-to-nearly-completely-digested fish with invertebrates until it is possible to take another fish. The digested condition of the fish prey of Bull Char may also suggest nocturnal feeding habits. In contrast, the stomach contents of Rainbow

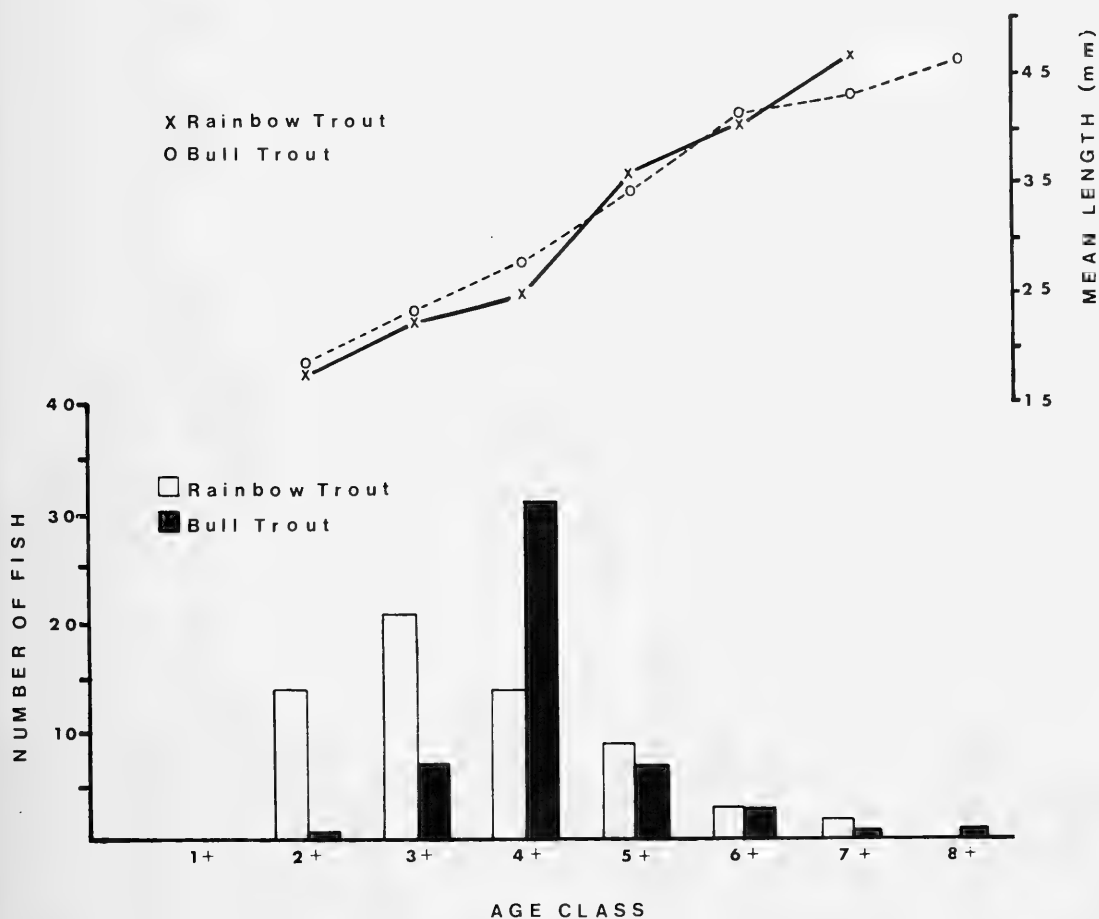


FIGURE 2. Frequency distribution of age classes and mean lengths of Rainbow Trout and Bull Char sampled from the Muskeg River system in Alberta.

Trout contained insects in all stages of digestion, from intact insects to remnants of the exoskeleton (head capsule).

Discussion

Bull Char comprised less than 15% of the fish angled in the Muskeg River drainage from May to August, 1984; the remainder were Rainbow Trout. There are several possible reasons for these unequal numbers, since angling may differentially select for one or the other species. Allen (1980: *unpublished report*, see above) found that angling was highly selective for Bull Char. If this were the case on the Muskeg River, it would suggest that the proportion of Bull Char in the sample may have exceeded that in the stream. If true, the salmonid population in the

Muskeg River must be heavily biased in favour of Rainbow Trout. Such differential vulnerability may also explain the apparent decline in Bull Char populations in Alberta.

It is noteworthy that the sampling technique used did not sample effectively fish of either species in the 1+ and 2+ age category. It is likely that the population size of these two age categories was significantly larger than in the older age categories, in which case the Bull Char may have been much better represented in the watershed than is suggested by this sample.

Overharvesting of fish by anglers in general could have contributed to the small numbers of Bull Char sampled in the drainage (W. Roberts, personal communication). The data in this study suggest that these fish become "catchable" when they are 3 to 4

TABLE 1. Mean length (mm) for seven age classes of Bull Char from the Muskeg and Clearwater rivers, Alberta.

River system	Age Class							Difference ^c
	2	3	4	5	6	7	8	
Muskeg	193(1) ^a	234(7)	276(30)	341(7)	402(3)	430(1)	462(1)	$P < 0.01$
Clearwater ^b	174(14)	215(21)	249(12)	298(5)	344(1)	395(1)	454(1)	

^aNumber of fish measured in parentheses.

^bData from Allen (1980).

^cBased on paired-t test.

TABLE 2. Food habits of Rainbow Trout and Bull Char, expressed as indices of relative importance^a, in two sections of the Muskeg River system in Alberta over the summer of 1984.

Food item	Location along the Muskeg River					
	Below beaver dam			Above beaver dam		
	May-June		July-August		July-August	
	Rainbow Trout	Bull Char	Rainbow Trout	Bull Char	Rainbow Trout	Bull Char
Invertebrates	13 533	2 588	15 997	9 210	18 131	7 864
Ephemeroptera	3 387	0	14 513	6 718	11 790	5 049
Plecoptera	1 124	1 470	205	764	1 370	982
Trichoptera	1 090	32	251	48	566	134
Diptera	7 762	186	630	900	3 274	986
Others ^b	165	900	398	780	1 131	713
Vertebrates	23	6 797	0	1 267	0	0
Fish ^c	0	6 769	0	1 267	0	0
Fish eggs	23	28	0	0	0	0
Detritus	37	182	9	0	81	91

^aIRI = (%Volume + %Total Items) (%Frequency); maximum value = 20 000 [(100 + 100) (100)].

^bIncludes: Annelida, Insecta — Orthoptera (Locustidae), Hemiptera (Corixidae), Coleoptera, Hymenoptera (Vespidae, Formicidae), and Crustacea — Amphipoda.

^cAll *Salmo gairdneri*, based on remnants of skin (black spotted), and ranged in size from 1+ to 3+ years based on extrapolations from bone sizes.

TABLE 3. Numbers of Bull Char captured with fish- and insect-imitating lures above and below a beaver dam complex on the Muskeg River, Alberta during the summer of 1984.

Lure type	Location		Difference ^a
	Above dam	Below dam	
Fish-imitating	9	17	$P < 0.001$
Insect-imitating	23	1	

^aBased on χ^2 for homogeneity.

years old. Public harvest by anglers in the same drainage in 1984 (personal observation) indicated that the majority of Bull Char taken were immature (less than 5 years old (Paetz and Nelson 1970)). Thus, excessive harvesting of immature fish would lead to a decline in the population.

Mature Bull Char may be at a competitive disadvantage with the introduced Rainbow Trout

when occupying the same stream. Allen (1980: *unpublished report*, see above) recommends Rainbow Trout as suitable for planting in streams with resident Bull Char populations, and data obtained in this study on stomach contents and size at a given age do not suggest that the two species are competing for food. If coexistence is hindering one species, the more likely candidate is the Rainbow Trout, since it formed an important part of the food base for Bull Char, at least in the lower portions of the Muskeg River drainage (Figure 3). However, based on the relative proportions of the two species in this stream, this level of predation by Bull Char on Rainbow Trout seems to have had no significant impact on populations of the latter.

Feeding habits of Bull Char in the Muskeg River can be summed up as follows. In the upper reaches of the Muskeg River above a beaver dam complex, which acted as a barrier to usual movements of fish in the system, Bull Char appeared to be insectivorous.

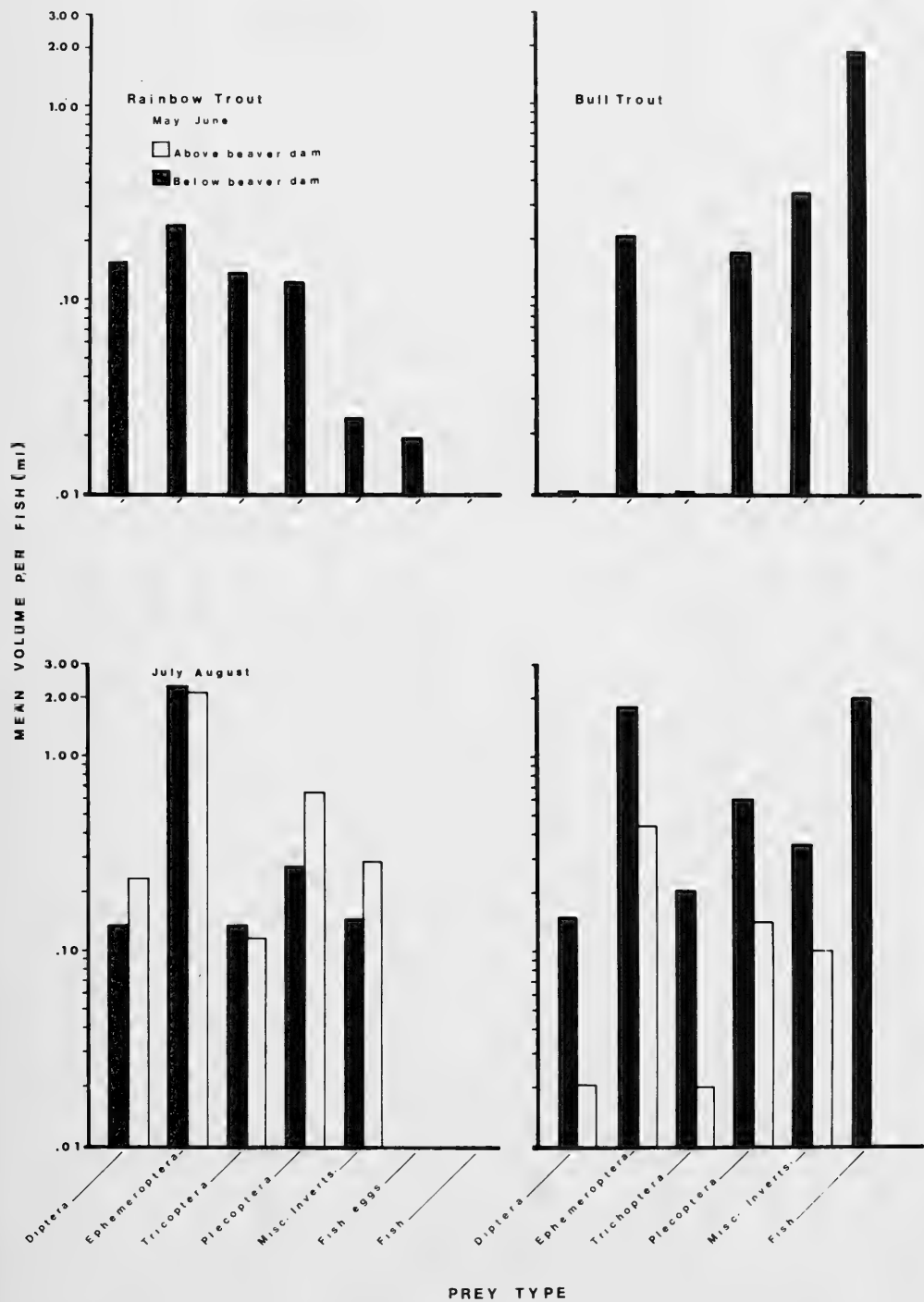


FIGURE 3. Mean volume of major food items taken from the stomachs of Rainbow Trout and Bull Char angled from the Muskeg river system in Alberta, May to August 1984.

By contrast, Bull Char residing below the beaver dam to the point where the Muskeg River crosses Highway 40 (Figure 1) fed on equal volumes of fish and insects. This suggests that the Bull Char either did not have ready access to small salmonids in the upper reaches or that Ephemeroptera were an abundant prey and easily taken. In either case, it suggests the species is somewhat opportunistic in its feeding habits. Roos (1959) found in the related anadromous Dolly Varden, another apparently opportunistic char, that invertebrates accounted for 79% of their stomach contents and Sockeye Salmon (*Oncorhynchus nerka*) parr accounted for 9%. Rainbow Trout seemed highly insectivorous throughout the sampled portions of the Muskeg River, a characteristic noted by Paetz and Nelson (1970) and Dietz (1971).

A generally held belief is that Bull Char are a threat to other native salmonids because they are piscivorous. Findings in this study support this belief, in that Bull Char were recorded feeding on fish, young Rainbow Trout in this instance. However, since Rainbow Trout became established in the Muskeg River in the face of Bull Char predation, this predation is most likely of little threat to the population of Rainbow Trout. Indeed, as the majority of fish eggs were recovered from the stomachs of Rainbow Trout, the possibility exists that Rainbow Trout may also be a threat to char eggs and as a consequence have a negative impact on the Bull Char population. A food habits study of these two species needs to be extended into the post-spawning period of the char to clarify this point. In summary, the introduction of Rainbow Trout into the Muskeg River system has led to a large population of this species in the drainage. This has made the stream more attractive to anglers who continue to harvest immature and mature Bull Char along with Rainbow Trout. Whether this has been to the detriment of the Bull Char is debatable. Certainly, Bull Char appear to pose no threat to the Rainbow Trout fishery.

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Literature Cited

- Armstrong, R. H., and R. F. Blackett. 1966. Digestion rate of the Dolly Varden. *Journal of Fish Biology* 27: 429-430.
- Armstrong, R. H., and W. M. Morton. 1969. Revised annotated bibliography on the Dolly Varden Char. Alaska Department of Fish and Game, Research Report Number 7. 108 pp.
- Cavender, K. 1978. Taxonomy and distribution of the Bull Trout, *Salvelinus confluentus* (Suckley), from the American northwest. *California Fish and Game* 64: 139-174.
- Crossman, E. J., and J. G. Hamilton. 1978. An apparatus for sampling gut contents of large, living fishes. *Environmental Biology of Fishes* 3: 297-300.
- Dietz, K. 1971. The fish populations of three streams in the Foothills of Alberta. M.Sc. thesis, University of Alberta, Edmonton, Alberta. 71 pp.
- Hynes, H. B. N. 1950. The food of the freshwater sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*) with a review of methods used in studies of the food of fishes. *Journal of Animal Ecology* 19: 36-58.
- Hyslop, E. J. 1980. Stomach contents analysis—a review of methods and their application. *Journal of Fish Biology* 17: 411-429.
- Kroquis, F. V., and E. M. Krokhin. 1948. Ob urozhaivosti molodoi krasnoi (*Oncorhynchus nerka* Walb.). *Izvestnoi Tikhookeanski Nauchnoe Institut Ryb Khozi Okean, Vladivostok* 28: 3-27. [On the production of young sockeye salmon. Translated by R.E. Foerster. Fisheries Research Board of Canada, Biological Station, Nanaimo, British Columbia. 1958.]
- Kvisle, N. 1983. The Kvisle Korner: Can we bring back the Bull Trout? *Western Canada Outdoors* 7: 4.
- Lagler, K. F., and A. T. Wright. 1962. Predation of the Dolly Varden, *Salvelinus malma*, on young salmon, *Oncorhynchus* spp., in an estuary. *Transactions of the American Fisheries Society* 91: 90-93.
- Meehan, W. R., and R. A. Miller. 1978. Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. *Journal of the Fisheries Research Board of Canada* 35: 1359-1363.
- Paetz, M. J., and J. S. Nelson. 1970. The fishes of Alberta. The Queen's Printer, Edmonton. 282 pp.
- Pinkas, L., M. S. Oliphant, and I. L. K. Iverson. 1971. Food habits of Albacore, Bluefin Tuna and Bonito in Californian waters. *California Fish and Game* 152: 1-105.
- Prince, E. D. 1975. Pinnixid crabs in the diet of young-of-the-year Copper Rockfish (*Sebastes bairinus*). *Transactions of the American Fisheries Society* 104: 539-540.
- Roos, J. F. 1959. Feeding habits of the Dolly Varden, *Salvelinus malma* (Walbaum), at Chignik, Alaska. *Transactions of the American Fisheries Society* 88: 377-379.
- Westaway, J. 1983. Trout troubles. *Alberta Report* 10: 21-22.
- Zemanek, R. 1983. The vanishing Bull Trout. *The Red Deer Advocate*, Saturday, April 9: 1C.

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Ecology of Island Muskrats, *Ondatra zibethicus*, Adapted to Upland Habitat

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The population structure, reproduction, and habits of Muskrats (*Ondatra zibethicus*) living on Damariscove Island, Maine, were studied from 1978 through 1982. The 85 ha island is 4.2 km from the mainland. Its vegetation is mainly coastal shrub and grassland with little freshwater or wetland areas typical of Muskrat habitat. The Muskrats live underground in burrows and use runways above ground. Their food supply is mainly upland vegetation. The average body weight of 701 animals obtained from fur trappers in the fall of each year was 976 g lower than the weight of mainland animals from northeastern North America as recorded in the literature. The Damariscove Island Muskrats have lower litter size (5.4 placental scars per litter) and lower litter frequency (1.4 per adult female) than mainland populations. However, because juvenile survival in summer is high (80%), the total production of surviving young per adult female at the end of the breeding season is similar to mainland populations. Sex ratio and age structure in fall are similar to mainland Muskrats. Low body weight and low reproductive rates may be related to poor quality or quantity of suitable food. Low predator pressure is probably the key factor in the adaptation of this island population to upland habitat.

Key Words: Muskrat, *Ondatra zibethicus*, island adaptation, population ecology, Maine.

Muskrats (*Ondatra zibethicus*) are considered to be semiaquatic (Errington 1963; Willner et al. 1980). They normally live in wetland habitats, such as marshes, shallow ponds, and along the banks of rivers and streams, and are anatomically specialized for a semiaquatic mode of life (Perry 1982). In 1977 I learned that Muskrats inhabited an island off the coast of Maine where there was little freshwater or wetland habitat. The primary objectives of this study were to describe how Muskrats utilized this atypical habitat and to study their population structure and reproductive activity. It is known that Muskrats may temporarily occupy dry land areas during times of drought (Errington 1963). No studies of living habits and ecology of Muskrats established in upland habitat appear in the literature.

Study Area

Damariscove Island lies off the mid-coast region of Maine in Lincoln County, 5 1/2 km south of Boothbay Harbor, 69°36' N, 43°46' W. It is 4.2 km from the nearest mainland point. The island is 85 ha, about 2.8 km long and 0.45 km at the widest. The island is basically a glaciated ridge of bedrock with the higher elevations exposed. A thin layer of glacial till covers the rest of the island with a depth of soil ranging from a few cm to over 2 m in pockets and depressions. Most of the soil is very rocky, fine sandy loam.

Temperatures of the central Maine coast have a July mean between 15°C and 20°C and a January

mean between -6°C and -5°C (Fobes 1946). Cool North Atlantic air masses keep the spring and summer climate cooler than inland regions. Total annual precipitation along the central Maine coast averages 117 cm. Fog is common in spring and summer — one day out of six on the average. Snowfall may total over 150 cm but seldom lasts on the island throughout the winter.

The vegetation of Damariscove consists mainly of low shrubs and grassland. Dense clumps of *Myrica pensylvanica*, *Spiraea latifolia*, and *Rosa rugosa* occupy about half the island, interspersed with grassland. Eight habitat or land cover types were described and mapped by Wargo and Wargo in their study of the island's plant ecology for the Nature Conservancy (1979, personal communication). These habitats are (1) coastal tundra and rock outcrop; (2) upland meadow and shrub; (3) wet meadow; (4) freshwater wetland and bog; (5) brackish pond; (6) beach berm; (7) salt marsh; and (8) bedrock at the shore. The area and percentage of the total island of each habitat is given in Table 5.

The wet meadow habitat is restricted to narrow swales in patches under 1 ha in size. All standing water present in the spring disappeared by mid-summer. The freshwater wetland habitat is found on four small patches under 0.2 ha in size where standing water is temporary. Narrow-leaved Cattail (*Typha angustifolia*), a favorite food plant of Muskrats elsewhere, covers only 15 m along the edges of one of these areas.

Methods

The information presented here was gathered during 13 visits to the island totalling 42 days from 1977 through 1982 and by examining 701 Muskrat carcasses given to me by trappers each fall. I went to the island each trapping season (late October or early November) to examine the freshly skinned carcasses when they were available. In the last two years trappers took most of their catch home, froze the animals, and gave me the carcasses in December after they had thawed and skinned them.

Body weights of the carcasses were measured to the nearest 5 g with a Pesola spring balance. A correction factor of 1.232 was used to multiply the carcass weight to obtain total body weight. This correction factor was obtained from the mean percentage of carcass weight of total weight for 67 animals weighed before and after skinning in 1979 (81.2%, SD = 2.44).

The sex and reproductive activity of each specimen was determined macroscopically. Reproductive tracts of females with uteri 2 mm or more in width or with placental scars were preserved in 10% neutral formalin and examined later in the laboratory with a dissecting scope. Undamaged skulls were removed and saved. These were later cleaned and the zygomatic breadth and condylobasal length measured with a dial calipers; the upper molar teeth were examined for wear under a dissecting scope. I used the methods of Pankakoski (1980) and Olsen (1959) to separate skulls into juvenile, or young of the year, and adults, or those born the previous year. Those skulls with the first buccal groove of the first upper molar continuing into the tooth socket were defined as juveniles.

Livetrapping was done during one week each in the summers of 1979 and 1981. The Muskrats captured alive were weighed, sexed, tagged with a numbered eartag, and released at the site of capture. The measurement of Muskrat utilization of different habitat types was done in July 1982 by walking transect lines over the island in a pattern chosen to cover all habitat types. The number of active runways which crossed the census line or came within 1 m of either side was recorded for each habitat type. In the tundra-rock outcrop habitat, where runways were not formed, the occurrence of fecal pellets within a 5 m section along the line or 1 m on either side was recorded as one count of Muskrat use.

Construction of surface runways and underground burrows was studied by mapping and excavating during the summers of 1979 and 1982. Eight burrow systems were excavated and two areas of runways were mapped in detail. The ponds and wetlands were checked during each visit to the island to see if lodges were being constructed. Records of activity were kept of all animals seen alive. A list of plants used by

Muskrats was compiled by observation of signs of plants eaten and of plant parts found fresh in burrows. Quantitative study of food habits was not a part of this study, however.

Results and Discussion

The Muskrat population of Damariscove Island is well established and breeding successfully, indicating the species' ability to adapt to upland habitats with a scarcity of water. Harvest by trappers began in 1972, although former Coast Guard residents of the island remember first seeing Muskrats on the island in the early 1940s (personal communications). Annual harvests since the start of this study have been approximately 360 in 1977, 460 in 1978, and at least 650 per year (7.6 per ha) for 1979, 1980, and 1981, with a decline to 84 animals in 1982 due to reduced trapper effort. Body size and certain demographic characteristics of this population differ from Muskrat populations in typical wetland habitats in northeastern North America and northcentral U.S.

Body weights, sex, and age ratios

The mean body weights for male and female Muskrats trapped in the fall from 1978 through 1982 are shown in Table 1. The mean weights for both sexes in the 1979 sample were greater than for other years ($F = 12.7, p < 0.01$), but I have no explanation for this difference. The overall mean weight was 976 g (range = 525 to 1600 g) with no significant difference between the sexes (980 g for males and 971 g for females). Eleven adults livetrapped in June and July, 1979, had a mean weight of 1093 g. The sex ratio in the fall samples favored males. The proportion of males in the trapped samples from 1978 to 1982 were 52.9%, 57.6%, 55.6%, 55.7%, and 58.0%. The proportion of males in the five-year sample was 55.6% ($\chi^2 = 9.1, p < 0.01$).

The Damariscove Muskrats weighed less than Muskrats from mainland habitats at similar latitudes. Errington (1963) reported mean weights for fall-

TABLE 1. Mean body weights (in g) of Muskrats from Damariscove Island from 1978 to 1982. All animals were collected in October and November by trappers. (Sample sizes in parentheses.)

	Male	Female	Total
1978	900 ± 177 (82)	883 ± 226 (73)	892 ± 201(155)
1979	1048 ± 289 (91)	1045 ± 213 (67)	1047 ± 258(158)
1980	967 ± 165(100)	1006 ± 214 (80)	984 ± 189(180)
1981	995 ± 179 (88)	945 ± 187 (70)	973 ± 185(158)
1982	993 ± 140 (29)	1002 ± 249 (21)	997 ± 191 (50)
Total	980 (390)	971 (311)	976 ± 214(701)

caught Muskrats in New York at 1588 g, in Michigan at 1044 g, and in Illinois at 1225 g. In Connecticut, Smith and Jordan (1976) found a mean weight of 1357 g in fall-caught animals. Only Newfoundland Muskrats are smaller than Damariscove animals in the geographic vicinity: mean weights of adults from two populations there were 874 g and 930 g (Rigby and Threlfall 1982). The subspecific status of Newfoundland Muskrats is based primarily on their smaller body size and cranial measurements relative to mainland samples.

Comparisons of the body size between closely related island and mainland populations of mammals have shown no clear, single trend, although there is a tendency for island rodents, mostly cricetine and microtine, to be larger than their mainland relatives (Foster 1964; Case 1978; Vaughan and Schwartz 1980). Arguments used to explain the larger size of island rodents include greater food supply, territorial behavior regulating access to food, relaxation of predator pressure, and temperature-energetic benefits (Lawlor 1982). Boyce (1978) concluded that food supply was the single most important factor influencing body weight of Muskrats over a wide geographic range, with "selection favoring smaller body size in areas of low food availability". Dozier et al. (1948) weighed over 23 000 Muskrats from Blackwater National Wildlife Refuge in Maryland from 27 separate management units over four years and found a "direct correlation between body size and weights of Muskrats and the quality and abundance of their food supply". Rigby and Threlfall (1982) attributed the small size of Newfoundland Muskrats to poor availability and nutritional value of food. Zucker and Chapman (1984) compared body weights and skull sizes of Muskrats from three regions of Maryland. Muskrats from the eastern shore were smaller than those from central and western regions. They suggested that the Muskrat food of the brackish coastal marshes was of lower quality than that of the freshwater habitats to the west.

Food availability and quality may be the major

factors for the reduced weights of Damariscove Muskrats compared with mainland populations. Their food supply is limited in winter and spring, and during the summer, nutritional quality may be lower than mainland wetland vegetation.

The ages of 574 Muskrats were estimated as juvenile or adult according to dental or cranial materials. Adult males and females averaged 1219 g and 1228 g, respectively. Juvenile males and females averaged 914 g and 867 g, respectively. The sex ratios of juveniles favored males in all years sampled (Table 2). The annual representation of males in the adult samples was consistently lower than in the juveniles and may result from increased natural mortality of males. Annual sex ratios on Damariscove were similar to mainland populations (Table 4). The preponderance of males in Muskrat populations is a general phenomenon (Perry 1982).

The annual juvenile to adult female ratios were 1978 - 4.50; 1979 - 3.77; 1980 - 5.64; 1981 - 12.18; and 1982 - 5.71. These ratios represent the productivity of the population after infant and juvenile mortality from birth to the fall trapping season. The 5 year average was 6.0 juveniles per adult female. These results are probably not biased by differential trap effectiveness or by differential dispersal among age groups. Other studies (e.g. Smith and Jordan 1976) have shown that Conibear traps, such as those used on Damariscove, are not selective with respect to animal size. No dispersal from the island was detected during this study. The water around the island never freezes and Muskrats were seen in ocean water on only two occasions when they swam across the 60 m wide inner end of the harbor inlet.

Reproduction

The mean number of placental scars per litter and the mean number of litters per female by year is given in Table 3. Where multiple litters occurred, scars from the most recent pregnancy appeared larger and darker than those from the first pregnancy. There were no signs of three litters in any female. The fecundity of 36

TABLE 2. Proportion of male to female in the adult and juvenile cohorts of Muskrats trapped from 1978 to 1982 on Damariscove Island.

	Adults			Juveniles		
	Males	Females	Percent Males	Males	Females	Percent Males
1978	14	18	43.8	49	32	60.5
1979	14	13	51.9	29	20	59.2
1980	11	25	30.6	86	55	61.0
1981	13	11	54.2	75	59	56.0
1982	3	7	30.0	26	14	65.0

TABLE 3. Female reproduction based on autopsy of fall-trapped Muskrats.

	N	Placental scars		Litters N	Scars per litter	Mean litter number
		total	\bar{x}			
1978	15	110	7.33	20	5.50	1.33
1979	12	73	6.08	16	4.56	1.33
1981	5	42	8.40	8	5.25	1.60
1982	4	45	11.25	6	7.50	1.50
Total	36	270	7.50	50	5.40	1.39

females with evidence of pregnancy was 1.4 litters per female and 5.4 scars per litter. The number of placental scars per female, the mean litter size, and the number of litters per year are all lower for Damariscove females than for mainland Muskrat populations (Table 4).

There were 7.5 placental scars per adult female and 6.0 juveniles per adult female in the fall samples, providing an estimate of 20% mortality from birth to the fall trapping season. This rate of juvenile mortality is lower than the estimates by the same method in other selected studies (Table 4). It is also lower than the 61% and 73% juvenile mortality in Massachusetts (Chamberlain 1951) and the 65% mortality in New York (Alexander 1951). The lower reproductive output on Damariscove is compensated by a higher survival rate of young in the summer so that the annual productivity is comparable to that docu-

mented in many mainland populations from similar latitudes.

Growth Rates

Twenty-four Muskrats were livetrapped and tagged in June and July 1979. Eight of these were recaptured by trappers in November 1979. Four young animals of one litter were tagged in July 1982 and three of those were recaptured in November 1982. Information on weight gain came from these 11 recaptured animals. The mean rate of weight gain for six juveniles was 4.03 g per day from July to early November. Four adults gained an average of 1.61 g per day while one adult lost 100 g from August to November. Parker and Maxwell (1980) found juvenile Muskrats in New Brunswick freshwater marshes gained 10.7 g per day for males and 6.7 g per day for females. This was more than twice the rate of growth for Damariscove

TABLE 4. Demographic data from Muskrat studies in northeastern and central North America.

Location	Percent males	Juvenile/ adult ♀	Percent juveniles	Plac. scars/ adult ♀	Litter size	Number litter/yr.	Percent juv. mort.	Reference*
Maine	58.0	5.7	72.0	14.8	5.4, 7.4	2.0		1
Connecticut	53.0	5.2	70.0					2
New Brunswick	56.3, 60.5	9.3	78.0, 82.0	17.0	6.8	2.5	45.0	3
Quebec		6.8	75.6		6.6	2.0	45.0	4
Wisconsin	55.5	7.1	78.0	15.5	6.3 - 8.0	2.0		5
Minnesota		4.8	72.7					6
Nebraska	57.8		71.0, 76.0, 83.0		6.7, 6.8, 7.1	2.5		7
Ontario		8.6	74.0, 85.0	12.7	6.3	2.0	33.6	8
Maine	55.6	6.0	77.5	7.5	5.4	1.4	20.0	This study

*1. Gashwiler 1950a & 1950b. 4. Stewart and Bider 1974. 7. Sather 1958.
2. Smith and Jordan 1976. 5. Beer and Truax 1950. 8. Proulx and Gilbert 1983.
3. Parker and Maxwell 1980. 6. McCann 1944.

juveniles. The low summer growth rates on Damariscove may be a result of poor quality food.

Food Habits

The plants which were recorded as being clipped by Muskrats on the surface of the island and which were found in the burrow systems were grass species, raspberry (*Rubus* sp.), spirea (*Spirea latifolia*), sedges (*Carex* sp.), rushes (*Scirpus* sp.), goldenrod (*Solidago* sp.), Yarrow (*Achillia millefolium*) and Scotch Lovage (*Ligusticum scoticum*). In addition, iris (*Iris versicolor*), Common Cattail (*Typha latifolia*), and Staghorn Sumac (*Rhus typhina*) were eaten in the few places where these plants occurred. The major food plants for Muskrats throughout their range are wetland and semiaquatic species (Willner et al. 1975). In the northeastern United States and Canada the most important food plant is the cattail. In times of environmental stress, when Muskrats are forced to feed beyond their normal wetland habitats, they will consume a wide variety of plants (Errington 1963). The Damariscove Muskrats subsist regularly on what would be an emergency diet elsewhere.

Reports of food caches in Muskrat burrows are scarce (Earhart 1969). Other researchers state that Muskrats rarely store food (Errington 1941; Schwartz and Schwartz 1959) and generally do not eat food in their nest area (Perry 1982). On Damariscove, I found fresh piles of forbs of the species listed above in three of the eight burrow systems examined. These appeared to be food supplies. I found no evidence that Muskrats on the island ate food from the intertidal zone or ocean shore.

Burrows and Runways

All of the Muskrats lived in underground burrows on the island. The burrows and connecting runways above ground were distributed over the entire island. Although no true lodges were constructed here, mounds of vegetation (grass, stems of flowering plants and matted root material) were formed over the mouths of a few burrows. The largest such mound was 1.3 m in diameter and 0.6 m high. The mean length of eight excavated burrows was 6.2 m (range 3 to 12 m). All burrows contained one or two chambers approximately 40 cm in diameter and nearly filled with a nest of dry, fine grass. The animals moved to and from the burrow entrances along well-worn runways resembling large vole runways in grassland. Some of these pathways were worn 6 to 8 cm below the surface of the surrounding soil, indicating years of usage.

During my visits in May, June, July, October, and November, Muskrats were underground during daylight hours. During one March visit with near freezing daytime temperatures I observed many

animals during mid-day, alone and eating or searching for food at the bases of grass clumps.

Burrows of Muskrats normally have entrances that open under water (Earhart 1969; Willner et al. 1980; Beshears and Haugen 1953). The length and complexity of burrows is determined by soil type, slope of land, and proximity to water. Earhart (1969) found three types of burrows of Muskrats living near farm ponds in California. These were extensive breeding burrows averaging 2 m in length, short temporary winter burrows, and short feeding burrows near food supplies. The bank burrows of Muskrats living in a northern marsh in Manitoba were used only during the summer (MacArthur and Aleksuk 1979). The seasonal shift from burrow to lodge in Manitoba was related to temperature needs of the animals. The thermoneutral zone of Muskrats in Colorado extended down to 10°C (Sherer and Wunder 1979). Muskrats in Manitoba were able to withstand low temperatures of -9°C within winter shelters (MacArthur and Aleksuk 1979). The moderate climate of Damariscove probably does not subject the Muskrats to stress of low temperature in spite of the lack of a consistent insulative snow cover.

Errington (1963) described elaborate and lengthy burrow systems maintained for decades by Muskrats in northcentral U.S. Some of these extended for over 100 m. Errington stated that such burrow systems resulted from construction by different individuals over the years to accommodate falling water levels in marshes. He found burrows in dry earth, unconnected to water, to be the work of transient Muskrats.

The upland habitat and lack of sufficient wetlands for lodge construction on Damariscove Island has led to the exclusive use of burrows for shelter throughout the year. These island Muskrats behave like many other species of microtine rodents which construct networks of runways, dig burrows underground, and build grass nests for birth and care of the young and as shelters against the cold (Johnson and Johnson 1982).

Habitat Use

A total of 4254 m of transect lines were surveyed for Muskrat runways in four habitat types which showed evidence of Muskrat use (Table 5). The index of Muskrat use for each habitat in numbers of runways per 100 m of transect line is compared by letting the index for freshwater wetlands equal 1.00. The wet meadow habitat had about one-half the use and the coastal tundra-rock outcrop and the upland meadow and shrub habitats had less than two-tenths of the use of the freshwater wetlands. Habitat use cannot be related to food choice from this data. Muskrats on Damariscove demonstrated an increasing preference for using habitats with increasing amounts of ground

TABLE 5. Habitat use by Muskrats on Damariscove Island and habitat availability. Habitats are given in hectares and percentage of total. Index of Muskrat use is runways per 100 m of transect line. (Length of line surveyed in m in parentheses.) Habitat use is compared by letting the freshwater index equal 1.

Habitat Type	Area	Percent	Index of Muskrat use	Ratio of use to freshwater wetland
1. Coastal tundra and rock outcrop	6.5	7.7	4.17 (240 m)	0.11
2. Upland meadow and shrub	59.5	70.3	15.7 (3297 m)	0.17
3. Wet meadow	8.1	9.6	46.8 (378 m)	0.52
4. Freshwater wetland	2.0	2.3	90.0 (99 m)	1.00
5. Brackish pond	3.2	3.8		
6. Beach berm	1.1	1.3		
7. Salt marsh	0.2	0.2		
8. Bedrock at shore	4.0	4.7		
Total	84.6	99.9		

moisture. Muskrats were seen swimming during nighttime in the shallow temporary ponds in the spring.

Predation

Predators of Muskrats were rare on the island. Apparently Mink (*Mustela vison*) will sometimes swim from the mainland to the island. A single Mink was trapped in 1977, another in 1980, and three Mink were trapped in 1982. Snowy Owls (*Nyctea scandens*) remain on the island for a few months during some winters. One Snowy Owl was present in February and March 1979, and I found Muskrat hair and bones in its pellets. Norway Rats (*Rattus norvegicus*) inhabit the island but there was no evidence that they preyed on Muskrats of any age.

Conclusions

This study shows Muskrats to be versatile in their use of habitats. This island population has occupied an upland habitat for over 40 years despite scarcity of standing water, wetlands, and the plant food typical of the species' normal environment. This population demonstrates the ecological release or niche expansion common among island populations. This is usually attributed to fewer competitors and predators on islands (MacArthur and Wilson 1967; Gorman 1979). I suggest that the virtual absence of permanent predators on Damariscove Island is the major factor in the success of the Muskrats there. Muskrats' evolutionary adaptation to semiaquatic habitats may have been a strategy for exploiting resources not readily available to most rodents, as well as for escaping predators. In the northern part of their range the aquatic environment serves the added advantage of moderating temperatures where soil and air

temperatures are too low to be tolerated.

The Damariscove Island Muskrats have adjusted their behavior to the upland habitat by constructing burrows and runways on dry land and have changed their food habits to utilize what is available. Lower quality of food is probably the major factor in their lower body weight compared with mainland Muskrats and may also account for lower litter size and litter frequency. However, high survival of young in the nearly predator-free environment results in normal productivity and continued success of the population in this upland habitat.

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Literature Cited

- Alexander, M. M. 1951. The aging of Muskrats on the Montezuma National Wildlife Refuge. *Journal of Wildlife Management* 15: 175-186.
- Beer, J. R., and W. Truax. 1950. Sex and age ratios in Wisconsin Muskrats. *Journal of Wildlife Management* 14: 323-331.

- Beshears, W. W., and A. O. Haugen. 1953. Muskrats in relation to farm ponds. *Journal of Wildlife Management* 17: 450-456.
- Boyce, M. S. 1978. Climatic variability and body size variation in the Muskrats (*Ondatra zibethicus*) of North America. *Oecologia* 36: 1-19.
- Case, T. J. 1978. A general explanation for insular body size trends in terrestrial vertebrates. *Ecology* 59: 1-18.
- Chamberlain, J. L. 1951. The life history and management of Muskrats on Great Meadow Refuge. M.S. thesis, University of Massachusetts, Amherst, Massachusetts. 68 pp.
- Dozier, R. B., M. H. Markely, and L. W. Llewellyn. 1948. Muskrat investigations on the Blackwater National Wildlife Refuge, Maryland, 1941-1945. *Journal of Wildlife Management* 12: 177-190.
- Earhart, C. M. 1969. The influence of soil texture on the structure, durability, and occupancy of Muskrat burrows on farm ponds. *California Fish and Game* 55: 179-196.
- Errington, P. L. 1939. Reactions of Muskrat populations to drought. *Ecology* 20: 168-186.
- Errington, P. L. 1941. Versatility in feeding and population maintenance of the Muskrat. *Journal of Wildlife Management* 5: 68-69.
- Errington, P. L. 1963. Muskrat populations. Iowa State University Press, Ames, Iowa. 665 pp.
- Fobes, C. B. 1946. Climatic divisions of Maine. *Bulletin of the Maine Technology Experiment Station*. 40: 1-44.
- Foster, J. B. 1964. Evolution of mammals on islands. *Nature* 203: 234-235.
- Gashwiler, J. S. 1950a. Sex ratios and age classes of Maine Muskrats. *Journal of Wildlife Management* 14: 384-389.
- Gashwiler, J. S. 1950b. Study of the reproductive capacity of Maine Muskrats. *Journal of Mammalogy* 31: 180-185.
- Gorman, M. L. 1979. Island ecology. Chapman and Hall, London. 79 pp.
- Johnson, M. L., and S. Johnson. 1982. Voles (*Microtus* species). Pp. 326-354 in *Wild mammals of North America*. Edited by J. A. Chapman and G. A. Feldhamer. Johns Hopkins University Press, Baltimore, Maryland. 1147 pp.
- Lawlor, T. E. 1982. The evolution of body size in mammals: evidence from insular populations in Mexico. *American Naturalist* 119: 54-72.
- MacArthur, R. A., and M. Aleksiuik. 1979. Seasonal microenvironments of the Muskrat (*Ondatra zibethicus*) in a northern marsh. *Journal of Mammalogy* 60: 146-154.
- MacArthur, R. H., and E. O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey. 203 pp.
- McCann, L. 1944. Notes on growth, sex, and age ratios, and suggested management of Minnesota Muskrats. *Journal of Mammalogy* 25: 59-63.
- Olsen, P. F. 1959. Dental patterns as age indicators in Muskrats. *Journal of Wildlife Management* 23: 228-231.
- Pankakoski, E. 1980. An improved method for age determination in the Muskrat, *Ondatra zibethicus* (L.). *Annales Zoologica Fennici* 17: 113-122.
- Parker, G. R., and J. W. Maxwell. 1980. Characteristics of a population of Muskrats (*Ondatra zibethicus*) in New Brunswick. *Canadian Field-Naturalist* 94: 1-8.
- Perry, H. R., Jr. 1982. Muskrats. Pp 282-325 in *Wild mammals of North America*. Edited by J. A. Chapman and G. A. Feldhamer. Johns Hopkins University Press, Baltimore, Maryland. 1147 pp.
- Proulx, G., and F. F. Gilbert. 1983. The ecology of the Muskrat, *Ondatra zibethicus*, at Luther Marsh, Ontario. *Canadian Field-Naturalist* 97: 377-390.
- Rigby, M. D., and W. Threlfall. 1982. A morphological comparison of Muskrats (*Ondatra zibethicus*) from Newfoundland and New Brunswick. *Canadian Journal of Zoology* 60: 2235-2238.
- Sather, J. H. 1958. Biology of the Great Plains Muskrat in Nebraska. *Wildlife Monographs* 2: 1-35.
- Schwartz, C. W., and E. R. Schwartz. 1959. The wild mammals of Missouri. University of Missouri Press, Columbia, Missouri. 341 pp.
- Sherer, J., and B. A. Wunder. 1979. Thermoregulation of a semi-aquatic mammal, the Muskrat, in air and water. *Acta Theriologica* 24: 249-256.
- Smith, H. R., and P. A. Jordan. 1976. An exploited population of Muskrats with unusual biomass, productivity, and body size. *Investigations of the Connecticut State Geological and Natural History Survey* 7: 1-16.
- Stewart, R. W., and J. R. Bider. 1974. Reproduction and survival of ditch-dwelling Muskrats in southern Quebec. *Canadian Field-Naturalist* 88: 429-436.
- Vaughan, T. A., and S. T. Schwartz. 1980. Behavioral ecology of an insular woodrat. *Journal of Mammalogy* 61: 205-218.
- Willner, G. R., G. A. Feldhamer, E. E. Zucker, and J. A. Chapman. 1980. *Ondatra zibethicus*. *Mammalian Species* 141: 1-8.
- Willner, G. R., J. A. Chapman, and J. R. Goldsberry. 1975. A study and review of Muskrat food habits with special reference to Maryland. *Publications in Wildlife Ecology, Maryland Wildlife Administration* 1: 1-25.
- Zucker, E. E., and J. A. Chapman. 1984. Morphological and physiological characteristics of Muskrats from three physiographic regions of Maryland, USA. *Zeitschrift für Saugtierkunde* 49: 90-104.

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Observations of Humpback Whale, *Megaptera novaeangliae* – Killer Whale, *Orcinus orca*, Interactions in Alaska: Comparison with Terrestrial Predator–prey Relationships

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Mammalian predator–prey interactions range from total disregard to active attack. Levels of interactions which occur during encounters between potential predators and their prey have been arranged into five classes. A comparison between the predator–prey relationships of Humpback–Killer whales and those of large African mammals is presented. Killer Whales are not always highly aggressive predators of other cetaceans, but instead, like lions in the terrestrial system, coexist in a usually non-belligerent, if uneasy, manner with those species able to defend themselves against attacks. Eighteen instances were recorded in which Killer Whales were within 1 km of Humpback Whales, and no aggressive interactions were witnessed. A situation is described having no terrestrial analogue, in which Humpback Whales, including small individuals and a female with a calf, joined with a pod of Killer Whales actively attacking a sea lion.

Key Words: Predator–prey interactions, Killer Whales, *Orcinus orca*, Humpback Whales, *Megaptera novaeangliae*, African ungulates.

Ungulates are the closest extant relatives of mysticete whales (Boyden and Gemeroy 1950), sharing many common anatomical, physiological, and, apparently, behavioral features. Although not exactly parallel, there exist striking similarities in many aspects of natural history and ecology between the large cetacea in the marine ecosystem and the large terrestrial ungulates (see Jarman 1974, and Leuthold 1977, for reviews of ungulate species; Gaskin 1982, for cetaceans). Thus, each attains a large body size, bears precocious young, undergoes extensive food-based migrations, maintains loose, large groups or herds composed of subgroups which disperse for feeding, feeds on patchily distributed but locally abundant food sources, and joins together when faced with predators. Healthy adults rarely flee single predators and may even initiate a charge as a deterrent; they are susceptible to attack only from large, social, cooperatively hunting predators. The Humpback Whale (*Megaptera novaeangliae*), in particular, may have as its terrestrial counterpart the large African open savanna ungulates such as the Wildebeest (*Connochaetes taurinus*), African Buffalo (*Syncerus caffer*), and African Elephant (*Loxodonta africana*).

The relationships between the large African ungulates and their predators (the African Lion, *Panthera leo*, Hyena, *Crocuta crocuta*, and Wild Dog, *Lycaon pictus*), have an extensive literature (e.g. Estes and Goddard 1967; Kruuk 1972; Schaller 1972). However, beyond fortuitous observations of attacks there is little information on the interactions between the large cetaceans and their occasional predator, the

Killer Whale (*Orcinus orca*).

The chief prey of Killer Whales are fishes, pinnipeds, and small cetaceans (Nishiwaki and Handa 1958; Rice 1968; Barr and Barr 1972). Attack and harassment by Killer Whales have been reported on Gray Whales, *Eschrichtius robustus* (Scammon 1874; Andrews 1914; Burrage 1964; Morejohn 1968; Baldrige 1972), Sei Whales, *Balaenoptera borealis* (Gaskin 1982), Blue Whales, *B. musculus* (Tarpy 1979), Minke Whales, *B. acoustirostrata* (Hancock 1965), Right Whales, *Eubaleaena glacialis* (Gaskin 1982), and Humpback Whales, *Megaptera novaeangliae* (Hubbs 1965; Whitehead and Glass 1985).

Although Killer Whales are predators of baleen whales, their daily coexistence is of a less belligerent nature than the few reports would imply, and seems to follow the more “normal” pattern of mutual regard and wariness exhibited by the African plains ungulates (Class D and E of Jarman 1974) and their large cooperatively hunting feline and canine predators.

Methods

All observations were made between the months of July and September 1979–1984 in the area of Frederick Sound, Alaska (57°20'N, 135°50'W). Individual Humpback Whales were photographically identified and followed for periods of up to 12 h from a 5.8 m inflatable boat. Size of individual whales was estimated visually. Respiration rates, dive patterns, and surface behaviors of focal whales were recorded continuously during observation sessions. All

surfacing of these humpbacks were plotted as well as those of contra- and con-specific individuals within approximately 1.6 km. SONAR (Datamarine Kodiak SLR modified for the study) and underwater hydrophone recordings (Uher 4200 Monitor, KSP Industries 117/224 hydrophone/preamplifier) were collected. Speeds were determined using a Datamarine LX80 Knotmeter.

Killer Whales were frequently seen moving through the area during the study period. Pod size varied from 1 to 18 individuals with a mode of 5. Potential prey for the Killer Whales is abundant in the area including

fishes, small cetaceans, and pinnipeds common in their diet.

Results

I have grouped interactions occurring between mammalian predators and their prey species into five general classes based on intensity, degree, and outcome of the interaction. Table I summarizes these five classes of interaction. All except *Class IV* have been documented in terrestrial predator-prey relationships; these have been thoroughly discussed elsewhere (i.e. Kruuk 1972; Schaller 1972). For *Class I*

TABLE I. Predator-Prey Interaction Classes

Interaction Class	Level of Interaction	Characteristics of the Interaction	Observations: species (author)	
			Savanna large mammal	Marine mammal
I	very low or none	No response on part of either predator or prey to the presence of the other; no detectable behavioral change; low activity level.	L.p.-C.t. (5)* P.l.-C.t. (15)	Observation I**
II	low or none	Predator approaches prey slowly; no overt change in behavior of prey beyond increased alertness; no aggressive behavior (rushes, etc.) by either; activity level low or moderate.	P.l.-C.t. (15) L.p.-C.t. (5) P.l.-S.c. (15) C.c.-C.t. (10) P.l.-L.a. (11)	Observation II
III	moderate	Prey moves off at approach of predator; no charge by predator; predator may or may not follow; no attack; activity level moderate or high.	P.l.-C.t. (15) C.c.-C.t. (10) L.p.-C.t. (5)	O.o.-E.r. (4,12,13)
IV	high	Prey join and mix with predator actively attacking another species but do not themselves join in the attack; no attempt at prey stealing; no overt aggression between predator and joining prey; activity level very high.		Observation III
V	high	Predator attacks prey (may or may not result in successful kill); prey fight or attempt escape; activity level very high.	P.l.-C.t (15) C.c.-L.p. (10) P.l.-S.c. (9,11,15) P.l.-L.a. (16)	O.o.-E.r. (1,2,3,13,14) O.o.-B.a. (7) O.o.-B.b. (6) O.o.-B.m. (17) O.o.-E.g. (6) O.o.-M.n. (6,8,18)

*Literature references: (1) Andrews 1914; (2) Baldrige 1972; (3) Burrage 1964; (4) Cummings and Thompson 1971; (5) Estes and Goddard 1967; (6) Gaskin 1982; (7) Hancock 1965; (8) Hubbs 1965; (9) Kraft 1973; (10) Kruuk 1972; (11) Leuthold 1977; (12) Ljungblad and Moore 1983; (13) Morejohn 1968; (14) Scammon 1874; (15) Schaller 1972; (16) Sikes 1971; (17) Tarpay 1979; (18) Whitehead and Glass 1985.

**Observation this paper.

C. t.: Wildebeest (*Connochaetes taurinus*); L. a.: African Elephant (*Loxodonta africana*); S. c.: African Buffalo (*Syncerus caffer*); C. c.: Hyena (*Crocuta crocuta*); L. p.: Wild Dog (*Lycaon pictus*); P. l.: African Lion (*Panthera leo*); B. a.: Minke Whale (*Balaenoptera acoustorostrata*); B. b.: Sei Whale (*B. borealis*); B. m.: Blue Whale (*B. musculus*); E. r.: Gray Whale (*Eschrichtus robustus*); E. g.: Right Whale (*Eubalaena glacialis*); M. n.: Humpback Whale (*Megaptera novaeangliae*); O. o.: Killer Whale (*Orcinus orca*).

and *II Interactions*, not previously reported involving cetaceans, and for *Class IV* which has been reported in no other group, I describe in some detail representative observations drawn from my study in Frederick Sound, Alaska between 1982 and 1984. Eighteen instances during which Humpback and Killer whales were within 1 km of each other were observed and accurate respiration and behavioral data were collected.

OBSERVATION I. (*Class I Interaction*) On 4 August 1982 we had accompanied a single adult Humpback Whale (estimated length 14 m) since 1604 h. The animal was following a meandering course at an average speed of 2.6 km/h, slowly travelling with brief periods of feeding interspersed. At 2037 h a pod of 18 Killer Whales was observed at approximately 0.8 km travelling at 3.7 km/h. The Humpback and Killer whales progressed at a converging angle of approximately 60 degrees. The humpback remained under observation until 2057 h, at which time we left it to photograph the Killer Whales. No change was noted in respiration, diving, behavior, or movement patterns that indicated a response by the humpback to the presence of the Killer Whales, nor did the Killer Whales appear to be aware of the humpback. The minimum distance separating the two species during the approach was approximately 0.6 km. I listened periodically for underwater vocalizations while near both species; all animals were silent during all sampling periods.

OBSERVATION II. (*Class II Interaction*) Between 1110 h and 1915 h on 3 August 1983, 15 Humpback Whales were dispersed over an area of 5.5 km². A cow (12-13 m in length) and an accompanying 7 m calf were apparently feeding near a steep ridge approximately 0.4 km from the nearest other humpback (a single 13 m adult which we had under observation). At 1415 a pod of six Killer Whales (two adult males, three females, and one subadult) fed briefly near the surface approximately 0.5 km from the cow and calf and 0.8 km distant from us; splashing, rapid surface rushes, and "porpoising" behavior were seen. The Killer Whales changed direction by approximately 45 degrees and swam slowly as a unit toward the cow and calf humpbacks, reaching them at 1426 h. The pod of Killer Whales then dispersed. Individual Killer Whales often swam to within 15 m of the humpbacks. The humpback cow made no discernible attempt to move the calf or herself out of the area, nor were there any detectable changes in respiration or behavior patterns. The Killer Whales remained in the vicinity of the humpbacks for approximately 12 minutes. By 1440 h the pod had regrouped and was slowly travelling off. The cow and calf humpback continued feeding in the area until at

least 1510 h. No underwater hydrophone recordings were made.

OBSERVATION III. (*Class IV Interaction*) On 13 August 1983 at 1225 h a pod of six Killer Whales (three adult females, one subadult male, one unsexed juvenile, and one calf) were observed harassing a single medium-sized Steller Sea Lion (*Eumatopias jubatus*), charging the animal singly or in groups of twos and threes. The sea lion was, on a number of occasions, struck by the tail of a Killer whale with force sufficient to throw it several meters across the water surface (see Figure 1). We were initially attracted to the scene by splashing visible at a distance of greater than 3.5 km.

At 1445 h a pair of 13-14 m Humpback Whales were observed approaching from approximately 1.8 km, and were within 50 m of the Killer Whales and sea lion at 1455 h. The humpbacks moved directly into the midst of the commotion where they then separated. The humpbacks were obviously very excited, as were the Killer Whales, all swimming rapidly at the surface on their sides, striking the flippers against the water surface, lobtailing, and lashing their flukes horizontally. Respiration rates of the humpbacks were significantly increased over the usual pattern and loud in-air vocalizations ("wheezes" and "trumpets") were emitted from their blowholes. Frequently the Humpback and Killer whales were in close proximity if not in actual physical contact.

They were joined at 1526 h by a small (10-11 m) single Humpback Whale; two additional singles and a pair joined within the next 40 minutes. At 1619 h (1 h 25 min after joining with the Killer Whales) three of the humpbacks moved off and apparently began to feed at a depth of 40-60 m, based on Sonar and ventilation patterns. Three other humpbacks moved off individually shortly thereafter. At approximately 1630 h a cow and calf humpback joined the Killer Whales, remaining in their midst for 1 h 45 min, until 1745 h. During this period there were three humpbacks with the Killer Whales: the cow and calf, and the small single who had joined at 1526 h and remained during the entire observation. The sea lion was no longer visible.

We stayed with two of the three humpbacks which had left at 1619 h for 2 h 09 min, until 1928 h, always within sight of the Killer Whales who continued to produce occasional bursts of activity and associated splashing. At 1930 h we reapproached the Killer Whales; there were now five Humpback Whales within 0.1 km with still no sign of the sea lion. At no time was there any indication of feeding by a humpback in the immediate vicinity of the Killer Whales. We left the area at 1945 h.



FIGURE 1. Killer Whale jumping over sea lion (visible directly beneath flukes of Killer Whale) after striking it with its tail. The ventral surface of the abdomen and flukes of the Killer Whale are pictured. Note the severed tip of right fluke. Photo by author.

Discussion

Interactions of *Class I* nature, described in Observation I, viz., each species apparently ignoring the other, appear to be the most typical situation, comprising 14 (80%) of 18 encounters which I observed. Interactions, or non-interactions, of this sort are also the most common among the terrestrial species, for potential predators are within perceptual distance of prey species during a significant proportion of the time. It may be that in these situations neither predator nor prey is aware of the presence of the other (unlikely), or the behavioral response may be so subtle as to be imperceptible to human observers; however, in either case no overt response ensues.

In *Class II Interactions*, frequently reported for open savanna ungulates, the predator(s) slowly approach the prey with no attempt at attack (i.e., no "rushes", etc.). While exhibiting signs of increased alertness, the potential prey may warily watch the predator move through their midst, often continuing to graze and making no attempt to move off, nor displaying any overt behavioral changes. The animals in these situations are certainly keying on subtle behavioral cues of the predator and these cues allow them to accurately assess the predator's intention and to determine the risk posed by their presence. Observations of the *Class II* type occurred in 3 (17%)

of the 18 documented encounters. In Observation II, typifying *Class II Interactions*, the Killer Whales changed course and approached the feeding cow and calf Humpback Whales. There was no evidence that the humpbacks responded in any way to the Killer Whales. It seemed unlikely that the Killer Whales moved into the vicinity of the cow and calf by chance, and inconceivable that the humpbacks and killers were not aware of the presence of the other. I would suggest that in these instances, as with the African ungulates, the predator is satiated or searching for more easily obtained prey items.

Assignment of interactions to *Class III*, in which the prey deliberately moves away at the approach of a predator, poses problems due to the difficulty of determining causal relationships between movements of predators and prey. Although numerous reliable reports exist for the terrestrial system, it is a situation especially difficult to document with cetaceans, due to both logistic difficulties of observations and lack of any clear behavioral indicators (e.g., alertness postures, sniffing, facing the approaching predator). There is some evidence that Gray Whales move away from the source of Killer Whale sounds in a playback experiment (Cummings and Thompson 1971). This may be construed as indicative of direct predator avoidance. A clear case of avoidance has been reported for Gray Whales fleeing into shallow water at

the approach of a pod of killers (Morejohn 1968); a less convincing case has been presented by Ljungblad and Moore (1983). I have observed no situation that could unequivocally be labelled avoidance of Killer whales by humpbacks in my study area during the study period.

Situations similar to that of Observation III, *Class IV Interaction*, rare in my experience (seen in only 1 (6%) of the 18 Humpback-Killer Whale encounters), have been reported by fishermen in southeast Alaska on at least one other occasion, having been initially mistaken for an attack. These observations perhaps offer an extension to the situation seen in the African large mammal predator-prey relationship. Even small single humpbacks and a cow with a calf (who would be defenseless against an attack) clearly approached and joined a pod of highly excited, aggressively behaving Killer Whales. Despite a high degree of interaction between the two species there was no sign of overt aggression.

Although Schaller (1972) reports prey approaching feeding predators after the kill has been made, I find no reports in which a mammalian prey species actively approached, joined, and mixed with a group of predators in the process of capturing and killing a prey other than for purposes of stealing the kill. The Humpback Whales did not actively participate in the attack on the sea lion. Although humpbacks often approached the sea lion closely, even making physical contact on at least one occasion, they did not appear to engage in any harassing behavior. Humpbacks restrict their diet to fishes and plankton; hence there was no question of predation upon the sea lion. One possibility may be that the surface commotion (splashing, breaching, and lobtailing) alone or in conjunction with vocalizations of either one or both species served as an attractive stimulus. Surface feeding Humpback Whales often produced a considerable amount of adventitious noise as they lunged out of and then fell back into the water. I have often witnessed humpbacks moving toward and joining up with other humpbacks feeding noisily at the surface; there may be a selective advantage to moving toward sounds of surface splashing, as it may indicate the presence of food. On the other hand, there is some evidence that both large and small cetaceans avoid the source of Killer Whale vocalizations (Cummings and Thompson 1971; Fish and Vania 1971). In Observation III high levels of vocalizations were produced by both species; therefore, the approaching humpbacks certainly were aware of the presence of the Killer Whales and did not perceive them as a threat to be avoided.

Schaller (1972) suggests that interactions of a *Class II* nature may be intentional teaching situations in which the young learn to judge safe distances to allow predators to approach; perhaps behavioral cues of the

predators are learned as well at this time. This would not, however, seem applicable to *Class IV Interactions*. It remains an open question why a humpback would approach, join, and remain in the Killer Whale group, since it was not apparently gaining any feeding or other obvious benefit from the association, and was, in fact, exposing itself to an increased risk of attack. Is this a situation unique to marine mammals?

Class V Interactions, in which an actual attack occurs, have been abundantly reported for both terrestrial ungulates and baleen whales. Katona et al. (1980) reports that 33% of the approximately 2800 Humpback Whales photographed in the Western North Atlantic bear scars from Killer Whale attacks; my observations in Alaska indicate a scarring rate of 15-20% (out of 350 identified individuals), comparable to the 18% frequency of scarred individuals reported in Pacific Gray Whales by Rice and Wolman (1971). (Although some scarring is possibly caused by sea lions, which have been observed "nipping" at humpback flukes, the parallel spacing of the scratches would indicate that they are tooth-rake marks of Killer Whales, False Killer Whales (*Pseudorca crassidens*), or possibly sharks. It is of some interest that new parallel scars appear more frequently on small humpbacks than on large adults.)

During more than 1200 hours of observation in the study area and over 40 hours of interaction between Humpback and Killer whales between 1979 and 1984, I have witnessed no attacks. I am aware of only one reliable report of an attack in the area during this period (D. McSweeney, personal communication). This low frequency of attack appears similar to the rate of attacks in other humpback feeding and breeding areas as well (e.g. western North Atlantic, Caribbean, Hawaii; author's observations and discussion with other researchers). Successful attacks, in which a kill is made by Killer Whales of baleen whales, are rare (Burrage 1964), as are attacks by lions on buffalo and elephants (Leuthold 1977). The paucity of attacks on Humpback Whales while on the feeding and breeding grounds and the observation that mainly small animals show new scars may indicate that it is young animals which are most susceptible to attack during migration when group size is probably low. The successful defense against predators may be due, in part, to the large size of the prey species, as well as to group defense behavior which has been exhibited by Humpback Whales (Whitehead 1985), elephants (Sikes 1971), and buffalo (Kraft 1973).

In summary, there appear to be many similarities in behavioral ecology between the baleen whales and the large savanna ungulates, their closest extant relatives. My observations indicate many similarities in their relations with predators; these also exhibit

similarities, since they comprise a few species, are large in size and cooperative in their hunting. Virtually all previous reports concerning interaction between baleen and Killer whales have involved attacks. The literature contains numerous reports of aggressive encounters between the two, disproportionate to their frequency of occurrence. The predator-prey relationship, in fact, closely resembles that between the terrestrial large African ungulates and the social carnivores, that is, one characterized by a non-belligerent, if uneasy, coexistence.

The marine and terrestrial environments have traditionally been relegated to separate spheres of investigation. There are, however, many striking parallels between the two which merit further examination. A comparative approach to their study would contribute much to our understanding of the relationship between ecology and social organization.

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Literature Cited

- Andrews, R. C.** 1914. Monographs of the Pacific Cetacea. 1. The California gray whale (*Rhachianectes glaucus* Cope). Memoirs of The American Museum of Natural History, Series 2. 1: 228-287.
- Baldrige, A.** 1972. Killer whales attack and eat a gray whale. *Journal of Mammalogy* 53(4): 898-900.
- Barr, N., and L. Barr.** 1972. An observation of killer whale predation on a dall porpoise. *Canadian Field-Naturalist* 86(2): 170-171.
- Boyden, A., and D. Gerneroy.** 1950. The relative position of the Cetacea among the orders of Mammalia as indicated by precipitin tests. *Zoologica* 35: 145-151.
- Burrage, R. G.** 1964. An observation regarding gray whales and killer whales. *Transactions of the Kansas Academy of Science* 67: 550-551.
- Cummings, W. C., and P. O. Thompson.** 1971. Gray whales, *Eschrichtius robustus*, avoid the underwater sounds of killer whales, *Orcinus orca*. *United States Fishery Bulletin* 69: 525-530.
- Estes, R. D., and J. Goddard.** 1967. Prey selection and hunting behavior of the African wild dog. *Journal of Wildlife Management* 31(1): 52-70.
- Fish, J. F., and J. S. Vania.** 1971. Killer whale, *Orcinus orca*, sounds repel white whales, *Delphinapterus leucas*. *Journal of Marine Research* 20: 149-162.
- Gaskin, D. E.** 1982. The ecology of Whales and Dolphins. Heinemann, Exeter, New Hampshire. 459 pp.
- Hancock, D.** 1965. Killer whales kill and eat a minke whale. *Journal of Mammalogy* 46: 341-342.
- Hubbs, C. L.** 1965. Data on speed and underwater exhalation of a humpback whale accompanying ships. *Hvalradet Skrifter* 48: 42-44.
- Jarman, P. J.** 1974. The social organisation of the antelope in relation to their ecology. *Behavior* 58(3,4): 215-267.
- Katona, S., P. Harcourt, J. Perkins, and S. Kraus.** 1980. Humpback Whales of the western North Atlantic: a catalogue of identified individuals. Second edition, College of the Atlantic, Bar Harbor, Maine. 169 pp.
- Kraft, T.** 1973. Buffalo kill lion. *Africana* 5: 36-37.
- Kruuk, H.** 1972. The spotted hyena: a study of predation and social behavior. University of Chicago Press, Chicago. xvi+335 pp.
- Leuthold, W.** 1977. African ungulates: a comparative review of their ethology and behavioral ecology. Springer Verlag, New York. 305 pp.
- Ljungblad, D. K., and S. E. Moore.** 1983. Killer Whales (*Orcinus orca*) chasing gray whales (*Eschrichtius robustus*) in the northern Bering Sea. *Arctic* 36(4): 361-364.
- Morejohn, G. V.** 1968. A killer whale-gray whale encounter. *Journal of Mammalogy* 49: 327-328.
- Nishiwaki, M., and C. Handa.** 1958. Killer whales caught in the coastal waters off Japan for the recent 10 years. *Scientific Reports of the Whale Research Institute* 13: 85-96.
- Rice, D. W.** 1968. Stomach contents and feeding behaviors of killer whales in the eastern North Pacific. *Norsk Hvalfangst-Tidende* 57: 35-38.
- Rice, D. W., and A. A. Wolman.** 1971. The life history and ecology of the gray whale (*Eschrichtius robustus*). American Society of Mammalogists, Special Publication Number 3. 142 pp.
- Scammon, C. M.** 1874. The marine mammals of the northwest coast of North America. J.H. Carmay and Company, San Francisco. 319 pp.
- Schaller, G. B.** 1972. The Serengeti lion: a study of predator-prey relations. University of Chicago Press, Chicago. 480 pp.
- Sikes, S. K.** 1971. The natural history of the African Elephant. Weidenfeld and Nicolson, London.
- Tarpy, C.** 1979. Killer whale attack! *National Geographic Magazine* 155: 542-545.
- Whitehead, H., and C. Glass.** 1985. Orcas (killer whales) attack humpback whales. *Journal of Mammalogy* 6(1): 183-185.
- Wilson, E. O.** 1975. Sociobiology. Harvard University Press. 697 pp.

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Microdistribution of Terrestrial Snails (Stylommatophora) in Forest Litter

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The microdistribution of nine litter-dwelling species of small terrestrial snails was investigated in three forest habitats over a period covering two years in southwestern Alberta. The results, based on 600 randomly-selected litter cores that penetrated the forest floor to a depth of 20 cm, showed that 1) snail density varied among forest habitats (maximal in a coniferous forest, where litter depth was greatest, intermediate in a deciduous forest, and minimal in a mixed-wood forest where litter depth was least); 2) snails were clumped both horizontally and vertically, but their distribution bore no relationship to the nature of either the shrub or ground level vegetation; 3) snails were recorded to maximum sampling depth but their density diminished with increasing depth; 4) vertical distribution changed over the period of the study with a general upward movement between May and August.

Key Words: Microdistribution, Stylommatophora, terrestrial snails, forest litter, active period, Alberta.

The distribution of terrestrial gastropods is influenced by the availability of food, shelter, and an appropriate microclimate (Boycott 1934; Likachev and Rammelmeier 1952). Nevertheless, most ecological studies of litter-dwelling terrestrial molluscs appear to be based on the assumption that these gastropods are either evenly or randomly distributed in the upper layers of the litter (e.g. Karlin 1961; Uminski 1979; Platt 1980; Van Es and Boag 1981).

In southwestern Alberta, the microdistribution of this group of molluscs showed a strong, positive association with the presence of trees (Boag and Wishart 1982), a relationship also found elsewhere (e.g. Burch 1956; Karlin 1961). By contrast, the nature of understory vegetation in forested habitats seemed unimportant to their local distribution (Getz 1974; Boag and Wishart 1982). The leaves of forest trees are the main contributors to the formation of organic litter on the forest floor (Lutz and Chanderler 1946), and so the species composition of the trees producing litter and the depth of the litter may be important to the survival, and hence distribution, of terrestrial molluscs. This hypothesis is strengthened by the observations of Boag (1985) who found that small snails of three genera, kept in outdoor terraria, spent most of the time below the surface of the litter. Yet, despite this apparent relationship between the distribution of litter and terrestrial gastropods, no quantitative investigation of the vertical distribution of these snails in the litter has hitherto been made.

In this study we addressed the following questions: 1) is the microdistribution of terrestrial snails - both horizontal and vertical - clumped? 2) to what depth do terrestrial snails occur in the litter and upper layers of

the soil? 3) how is the depth distribution influenced by the organic content of the surface layers? 4) does the vertical distribution of these snails change over the active period (the period when minimum daily temperatures remain mainly above 0°C - May to August)?

Study Area

This study was carried out in the high foothills (1500 m elevation) of southwestern Alberta, within the Sheep River Wildlife Sanctuary (114°35'W, 50°40'N). Three forest types were selected: deciduous, mixed-wood, and coniferous. Within each, we established a 1 ha grid that was used to locate randomly selected sampling sites. Plant coverage in the shrub and ground layers was estimated at each sampling site according to the methods of Daubenmire (1959).

The deciduous forest habitat, located on a south-facing slope, was completely surrounded by grassland. Trembling Aspen (*Populus tremuloides*) dominated the tree layer and formed a closed canopy over most of the area sampled. The shrub layer was poorly represented (< 10% coverage), and the herb layer was dominated by Gramineae and Fireweed (*Epilobium angustifolium*). The litter layer varied from 5 to 7 m thick with a humus layer beneath it of about equal thickness.

The mixed-wood habitat was located on a well-drained, old river terrace ca. 1.5 km southwest of the deciduous forest. The canopy was generally open and the overstory was heterogeneous. Patches of Lodgepole Pine (*Pinus contorta*) were interspersed among Trembling Aspen, Balsam Poplar (*Populus balsamifera*), and young White Spruce (*Picea glauca*).

The shrub layer was relatively well represented (ca. 20% coverage), but the herb layer was relatively sparse. The litter layer varied from 0.5 cm and the humus layer from 2.4 cm in depth.

The coniferous forest was located along a small intermittent stream ca. 1 km west of the mixed-wood forest. The canopy was generally closed and the tree layer was dominated by White Spruce, with a few old Balsam Poplars. Both the shrub and the herb layers were very sparse (< 5% coverage). The litter varied from almost none to at least 30 cm, while the humus layer varied from 15 to 20 cm. Further particulars about the vegetation in these communities can be found in Locasciulli (1984).

Methods

Soil temperature was monitored over the year in one of the habitats sampled (deciduous forest) by placing a thermograph (Peabody-Ryan Model J) with the temperature sensor in the surface layer of the litter. An index of rainfall, another factor assumed important in the microdistribution of snails (Boag 1985), was made by recording precipitation with a garden pluviometer at a location approximately equidistant from each of the three forest communities.

At the end of each month, in the period from May to August in both 1980 and 1981, we collected 25 samples of litter and upper horizons of the soil from each of the three forest habitats. The sampling sites were determined from calculator-generated random numbers. The coordinates of these locations were established by measuring from reference points on the grid laid out in each forest.

Samples were taken with a steel corer that measured 6.2 cm in inside diameter and 20.0 cm in length. Each core was subdivided into 4 equal subsamples, each 5 cm deep. From top to bottom they were referred to as subsamples I, II, III and IV. Subsample I usually was composed mostly of litter. At each site sampled, four cores were taken so that each subsample came from a separate core, making the subsamples statistically independent. Each subsample was placed in a plastic bag and stored at ambient temperature until analyzed. We classified each subsample into one of two categories based on estimated content of litter (decaying leaves and wood particles): 1) abundant (> 33% by volume of litter), and 2) scarce (< 33% by volume of litter). We washed the samples through a set of sieves of decreasing mesh size (Newell 1971). The residue retained on each sieve was dried with a 1500-watt fan heater. Residue from the coarser sieves was hand sorted; residue from the smallest-meshed sieve (0.77 mm) was examined under a dissecting microscope (6x). Identification of recovered snail shells was based on Pilsbry (1946, 1948) and Burch

(1962). Only shells that lacked signs of erosion were included in the analyses; they were assumed to represent the living individuals at the time of collection. Voucher specimens of all species recovered were deposited in the Museum of Zoology (terrestrial gastropod catalogue numbers 1006 to 1015), University of Alberta, Edmonton, Alberta.

Because the same data set was subjected to several analyses, the critical level of significance was adjusted accordingly (i.e. Kirk 1968) using the Bonferroni formula $\alpha = 1 - (1-P)^n$ in which P is the adjusted new critical probability level; α , the normally accepted probability level (0.05); and n , the number of tests performed.

Results

Eleven species of terrestrial snails (Stylommato-phora) were recorded from the core samples. Two of these species (*Vallonia* sp. and *Vitrina alaskana*) were recovered only rarely and their shells were difficult to classify as to freshness — for this reason they were not included in the analysis. Furthermore, *V. alaskana*, because of its fragile shells, was rarely recovered intact and hence probably was under-represented in the samples. The remaining nine species formed the data base used in addressing the questions posed in the introduction.

A total of 1858 fresh snail shells was recovered from the 600 samples taken in the three habitat types over the two years of the study (Table 1). There was no significant difference in numbers recovered between years, but decidedly more snails were recorded in July than in August. The number of snails recovered from the three forest habitats also differed: 59% came from the coniferous forest, 34% from the deciduous forest, and 7% from the mixed-wood forest.

The horizontal distribution of the snails within the three forest habitats was non-random (Locasciulli 1984). For each of the monthly collections the variance exceeded the mean number of snails per sample in all cases, significantly so in 8 of 12 cases, indicating either a clumped distribution or a tendency towards it (Zar 1974).

A multiple correlation analysis, in which the number of snails of each species at a given location was considered in relation to the coverage of the species of forest floor vegetation at that location failed to show any positive or negative relationships (Locasciulli 1984). We conclude from this that the nature of the forest floor vegetation had little impact on the horizontal distribution of these snails.

The vertical distribution of the snails was also non-random. Snails were recovered in significantly greater numbers in the top 5 cm subsample of the cores than in any of the other three (Table 2). The proportion of

TABLE 1. Number of fresh shells of all species of terrestrial snails recovered from 600 core samples collected in three forest habitats over the frost-free season of 1980 and 1981.

Month	1980				1981			
	Decid- uous	Mixed- wood	Coni- ferous	Total	Decid- uous	Mixed- wood	Coni- ferous	Total
May	163	13	61	237	71	23	134	228
June	65	24	176	265	47	4	166	217
July	92	34	181	307	51	19	217	287
August	76	18	73	167	61	6	83	150
Total	396	89	491	976	230	52	600	882

Based on ANOVA split-plot: $\alpha = 0.0064$
 Difference between years: $F = 7.66$, df 1, 3;
 $P = 0.0670$
 Difference among months: $F = 44.89$, df 2, 3;
 $P = 0.0054$
 Difference among forest types: $F = 15.22$, df 2, 12;
 $P = 0.0005$

snails recovered below the top 5 cm seemed to be related to the depth of the litter: the coniferous forest with the deepest litter had 48% of the total below the top 5 cm, the deciduous forest with intermediate amounts had 36% of the total below this depth, and the mixed-wood forest, with the shallowest litter, had only 9% of the total below this depth. That these snails were dependent in their distribution on the nature of the litter layer was supported by a positive association between the presence of snails and the presence of organic matter in the core subsample. Thus, where the organic matter was $> 33\%$, there were 381 samples with snails present and 958 samples with snails absent, whereas, where organic matter was $< 33\%$, there were 6 samples with snails present and 597 samples with snails absent; $\chi^2 = 194.7$, $P < 0.0001$.

The species composition and relative abundance of snails in the three forest habitats are shown in Table 3. Members of the Pupillidae numerically dominated all three communities. *Vertigo gouldi* was most abundant in the deciduous forest, whereas *V. modesta* was most abundant in the coniferous forest. In the mixed-wood forest their numbers, although much lower than in either of the other two, were about equal. Of the two species of the Endodontidae, only *Discus cronkhiitei* was present in numbers that exceeded 10% of the total, and only in the forest habitats where deciduous trees were an important component of the overstory. Likewise, among the Zonitidae, only *Euconulus fulvus* was present in numbers that exceeded 10% of the total, and again, only in forests with a large component of poplar in the overstory. This distribution changed over time; there

was a trend among snails to move toward the surface between May and August (Table 4). This apparent movement is reflected in the mean depth at which snails were found each month, all habitats combined (May — 7.65 cm, June — 5.18 cm, July — 5.97 cm, August — 4.05 cm).

Among the species of snails recorded in this study, some seemed to remain in the more surficial layers of the litter (*Vertigo* spp. and *Euconulus*), whereas other species tended to remain in the deeper layers (*Columella* spp., the endodontids *Punctum* and *Discus*, and the zonitid *Retinella*) (Table 4).

The snails recovered in this study exhibited a clumped pattern of dispersion in both the horizontal and vertical planes. The vertical distribution of terrestrial snails extended down at least 20 cm into the forest floor, the depth apparently controlled in large part by the depth to which the organic layer extended. Nevertheless, the snails were much more abundant in the top 5 cm of the litter than at greater depths. Moreover, in all forest habitats more snails were recovered from deeper layers of the core samples in May than later in the active season, suggesting an upward movement with the seasonal warming of the soil.

Discussion

The results of this study suggest that within forest habitats, snails are found mainly where forest litter is present, a relationship also documented elsewhere (e.g. Burch 1955; Cameron 1973). The differences in density of snails among forest habitats apparently reflect differences in litter depth. A deep and

TABLE 2. Number of snails (all species combined) recovered from 600 core samples taken at four depths in three forest habitats.

Forest type and mean litter depths	Month	Depth (cm) in the core sample				Total
		0-5	5-10	10-15	15-20	
Deciduous 6 cm	May	88	39	73	34	234
	June	77	32	3	—	112
	July	104	28	6	5	143
	August	130	4	3	—	137
Percentage of total		64	16	14	6	100
Mixed-wood 2 cm	May	30	1	3	2	36
	June	27	—	1	—	28
	July	50	2	—	1	53
	August	21	3	—	—	24
Percentage of total		91	4	3	2	100
Coniferous 15 cm	May	97	43	29	26	195
	June	190	103	32	17	342
	July	173	115	93	17	398
	August	110	19	15	12	156
Percentage of total		52	26	15	7	100
Difference						

Based on Friedman's ANOVA; depths joined by solid line not different from one another.

TABLE 3. Number (percentage) of different species of terrestrial gastropods recovered from 600 core samples taken from three forest habitats in southwestern Alberta during the period May-August, 1980 and 1981.

	Deciduous forest		Mixed-wood forest		Coniferous forest	
Pupillidae						
<i>Columella</i> spp. ^a	24	(4)	2	(1)	152	(14)
<i>Vertigo gouldi</i>	287	(46)	35	(25)	37	(3)
<i>Vertigo modesta</i>	25	(4)	37	(26)	570	(52)
Immature ^b	77	(12)	24	(17)	210	(19)
Endodontidae						
<i>Punctum pygmaeum</i>	43	(7)	2	(1)	20	(2)
<i>Discus cronkhitei</i>	85	(14)	24	(17)	44	(4)
Zonitidae						
<i>Euconulus fulvus</i>	68	(11)	15	(11)	30	(3)
<i>Retinella electrina</i>	3	(1)	2	(1)	15	(1)
<i>Zonitoides arboreus</i>	14	(2)	—	(0)	13	(1)
Total	626		141		1091	

^a*C. alticola* and *C. edentula* equally represented.

^b*Columella* spp. and *Vertigo* spp.

varied by as much as 95 mm during given sampling periods of the two years (Locasciulli 1984).

Boag and Wishart (1982) recorded maximum numbers of snails in August, from 1979 to 1981, based on permanent plots (Boag 1982). This is not surprising in view of the results of this study which suggest that during August the majority of molluscs, particularly the Pupillidae, inhabit the top 5 cm of the litter. Locasciulli (1984) found that the patterns of distribution of juvenile and adult papillids did not differ from one another. Furthermore, the average size of individuals of the other species recovered did not vary significantly over the sampling period, suggesting that juvenile and adult stages followed a similar pattern in their horizontal and vertical distribution, at least from May to August in the habitat types analyzed. Thus, in sampling snail populations one must take into consideration not only the clumped distribution in both horizontal and vertical space, but also the changing vertical distribution over time, as shown in this study.

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Literature Cited

- Boag, D. A. 1982. Overcoming sampling bias in studies of terrestrial gastropods. *Canadian Journal of Zoology* 60: 1289-1292.
- Boag, D. A. 1985. Microdistribution of three genera of small terrestrial snails (Stylommatophora: Pulmonata). *Canadian Journal of Zoology* 63: 1089-1095.
- Boag, D. A., and W. D. Wishart. 1982. Distribution and abundance of terrestrial gastropods on a winter range of bighorn sheep in southwestern Alberta. *Canadian Journal of Zoology* 60: 2633-2640.
- Boycott, A. E. 1934. The habits of land Mollusca in Britain. *Journal of Ecology* 22: 1-38.
- Burch, J. B. 1955. Some ecological factors of the soil affecting the distribution and abundance of land snails of eastern Virginia. *Nautilus* 69: 62-69.
- Burch, J. B. 1956. Distribution of land snails in plant associations in eastern Virginia. *Nautilus* 70: 60-64.
- Burch, J. B. 1962. How to Know the Eastern Land Snails. Wm. C. Brown Co., Dubuque, Iowa.
- Cameron, R. A. D. 1973. Some woodland mollusc faunas from southern England. *Malacologia* 14: 355-370.
- Chatfield, J. E. 1975. A summary on studies on food and feeding in some European land snails. *Malacological Review* 8: 123-125.
- Clarke, A. H., J. P. Kelsall, and G. R. Parker. 1968. The land snail fauna of Fundy National Park, New Brunswick. National Museum Canadian Contributions in Zoology Bulletin 4, 223: 5-22.
- Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. *Northwestern Science* 33: 43-64.
- Getz, L. L. 1974. Species diversity of terrestrial snails in the Great Smoky Mountains. *Nautilus* 88: 6-9.
- Karlin, E. J. 1961. Ecological relationship between vegetation and distribution of land snails in Montana, Colorado, and New Mexico. *American Midland Naturalist* 65: 60-66.
- Kirk, R. E. 1968. Experimental design for behavioral sciences. Brooks/Cole Publishing Co., Belmont.
- Likhachev, I. M., and E. S. Rammel'meier. 1952. Terrestrial mollusks of the fauna of the U.S.S.R. *Akademiya Nauk SSSR. Zoologicheskii Institut*. [Translated from Russian.] Published for the National Science Foundation, Washington, D.C., by the Israel Program for Scientific Translations, Jerusalem, 1962.
- Locasciulli, O. 1984. Distribution and abundance of terrestrial snails in three habitat types in southwestern Alberta. M.Sc. thesis, University of Alberta, Edmonton.
- Lutz, H. J., and R. F. Chanderler. 1946. Forest soils. John Wiley, New York.
- Newell, P. F. 1971. Quantitative soil ecology: population, production and energy flow. Edited by J. Phillipson. Blackwell Scientific Publications, Oxford.
- Pilsbry, H. A. 1946. Land Mollusca of North America (North of New Mexico). Volume 2, Part 1. Academy of Natural Sciences of Philadelphia, Monograph 3.
- Platt, T. R. 1980. Observations on the terrestrial gastropods in the vicinity of Jasper, Alberta (Canada). *Nautilus* 94: 18-21.
- Silvola, T. 1964. On the land mollusks of the Kevojoki River Valley in Finnish Lapland. Reports from the Kevo Subarctic Research Station. Turku University, Turku, Finland.
- Uminski, T. 1979. Life history in *Eucobresia nivalis* (Dumont et Mortillet) with notes on two other Vitrinidae (Mollusca, Gastropoda). *Bulletin de l'Académie Polonaise de Biologie* 3: 205-210.
- Van Es, J., and D. A. Boag. 1981. Terrestrial molluscs of central Alberta. *Canadian Field-Naturalist* 95: 75-79.
- Walden, H. W. 1981. Communities and diversity of land molluscs in Scandinavian woodlands. I. High diversity communities in taluses and boulder slopes in SW Sweden. *Journal of Conchology* 30: 351-372.
- Zar, J. H. 1974. Biostatistical analysis. Prentice-Hall Inc., Englewood Cliffs, New Jersey.

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Summer and Winter Food Caches of the Heather Vole, *Phenacomys intermedius*, in Quetico Provincial Park, Ontario

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Nagorsen, David W. 1987. Summer and winter food caches of the Heather Vole, *Phenacomys intermedius*, in Quetico Provincial Park, Ontario. *Canadian Field-Naturalist* 101(1): 82-85.

Summer food caches of the Heather Vole (*Phenacomys intermedius*) contained mostly leaf and stem cuttings from Blueberry (*Vaccinium angustifolium*) and Bearberry (*Arctostaphylos uva-ursi*) stored near burrows. Winter caches comprised piles of twigs that were cut from at least 17 species of broad-leaved shrubs and trees. Summer caches provide protection from predators while feeding; winter caches may represent food hoarding.

Key Words: Heather Vole, *Phenacomys intermedius*, food caches, Ontario.

A characteristic of the Heather Vole, *Phenacomys intermedius*, is its habit of making summer and winter food caches (Foster 1961). Most studies of these food caches were made in the boreal forests of eastern Canada (Foster 1961; Nagorsen 1982) or in subalpine and alpine habitats in western North America (Shaw 1924; Racey 1936). In the summers of 1977-79 during a small mammal survey of Quetico Provincial Park, I found a number of winter and summer food piles of *P. intermedius*. They provide data on the food habits of *P. intermedius* in the mixed forests of the Great Lakes - St. Lawrence Forest Region where this vole is at the southern periphery of its geographic range.

Study Area and Methods

Food caches were found in coniferous and mixed forests at Reid Lake (48°18'N, 91°21'W), Emerald Lake (48°07'N, 91°14'W), and Kawa Bay (48°24'N, 91°08'W) while sampling these habitats with transects of small mammal traps. These were mature forests that regenerated from major fires in the late 1800s and early 1900s. The only logging in these sites was selective cutting for Red Pine (*Pinus resinosa*) and White Pine (*Pinus strobus*) 40 to 60 years ago. Dominant trees were Jack Pine (*Pinus banksiana*), Balsam Fir (*Abies balsamea*), Black Spruce (*Picea mariana*), White Spruce (*Picea glauca*), Trembling Aspen (*Populus tremuloides*), and White Birch (*Betula papyrifera*). Mountain Maple (*Acer spicatum*), Red Maple (*Acer rubrum*), Green Alder (*Alnus crispa*), and Beaked Hazel (*Corylus cornuta*) were the most common shrubs. The forest floor was covered with numerous fallen trees (i.e. blowdowns) and decaying stumps. Nagorsen and Peterson (1981) have described the small mammal communities in these forests.

Plant cuttings collected from summer food piles were labelled and stored in a plant press for future identification. Twigs from winter caches (Figure 1)

were collected from the forest floor and stored in plastic bags. I recorded species of woody plants in the vicinity of each twig pile and noted any woody plants that were gnawed by small rodents. A reference collection of branches and stems from woody plants in the study areas was prepared to assist in identification. I used the following features to identify twigs: arrangement of branches, colour and texture of bark, arrangement of bud scales, morphology of lenticels, and the colour and texture of pith.

Results and Discussion

Summer Caches

Thirteen summer caches were found that I attributed to *P. intermedius*. They consisted of leaf and stem cuttings from various green plants that had been piled in or near burrows. Four species were identified in the 13 food piles; their frequency of occurrence was Blueberry (*Vaccinium angustifolium*) 69.2%, Bearberry (*Arctostaphylos uva-ursi*) 61.5%, Sweetgale (*Myrica gale*) 7.7%, and hawkweed (*Hieracium* sp.) 7.7%. Although the Rock Vole (*Microtus chrotorrhinus*) and Southern Red-backed Vole (*Clethrionomys gapperi*) also inhabited these forests, there was strong circumstantial evidence that these food piles were made by *P. intermedius*. The only voles taken in traps set near these caches were *P. intermedius*. Moreover, I trapped one Heather Vole during the study with Blueberry cuttings in its mouth. Food piles of the Rock Vole in Quetico Provincial Park contained mostly cuttings of Bunchberry (*Cornus canadensis*), Wild Lily-of-the-Valley (*Maianthemum canadense*), and Large-leaved Aster (*Aster macrophyllus*) [unpublished data].

Cuttings of Bearberry and Blueberry plants were reported in *P. intermedius* caches at Peninsula Harbour, Ontario (Miller 1897) and Authier-Nord, Quebec (Foster 1961). In eastern Canada, berries, leaves and twigs of these plants are an important item



FIGURE 1. Winter cache of cut maple (*Acer rubrum* and *A. spicatum*) twigs. Note that most twigs have been stripped of bark. Lens cap is 50 mm in diameter.

in the summer diet. Evidently there is strong selection for heather plants (Ericaceae) by *P. intermedius* during summer. Although Blueberry and Bearberry were common ground plants in the forests where I found Heather Vole caches, these habitats also supported a rich diversity of forbs that were not exploited by *P. intermedius*. Summer food piles of the Heather Vole that I collected contained small quantities of plant material that would be consumed within a day or two. Because of the abundance of food resources, it is unnecessary for *P. intermedius* to store large food reserves in summer. Caching small amounts of food at burrows is probably a strategy for avoiding predators while feeding.

Winter Caches

A total of 65 separate winter caches was collected. They consisted of cut twigs piled on the forest floor (Figure 1). Size of tooth marks indicated that twigs were cut by a small cricetid or microtine rodent. Although four species of small rodents (Deer Mouse, *Peromyscus maniculatus*, Southern Red-backed Vole, *Clethrionomys gapperi*, Rock Vole, *Microtus chrotorrhinus*, and *P. intermedius*) were trapped in forests with twig caches, I attribute these caches to *P. intermedius*. There are no reports in the literature that

P. maniculatus, *C. gapperi*, or *M. chrotorrhinus* cache twigs in winter. But several studies (Shaw 1924; Foster 1961) demonstrated that *P. intermedius* feeds on bark and caches twigs during winter. Moreover, Foster (1961) observed that this vole made piles of willow twigs in captivity.

Twig piles were found at the base of shrubs and tree saplings, near old burrows, under rocks and logs (Figure 1), and under the branches of fallen trees. Branches and stems of woody plants near twig piles were usually girdled and the tips of many branches were gnawed off. Some of these stems and branches were 1 to 2 m above the ground and, as *P. intermedius* is not arboreal (Johnson 1973), they could only be reached when there was deep snow cover on the ground. The absence of fresh droppings and green twigs in caches was additional evidence that twig piles were made the previous winter.

Number of twigs in caches varied from about 6 to 12 in small caches to more than 1200 in several large caches. Mounds of dried rodent droppings were present in large caches. From incisor marks on the ends of twigs, it was evident that twigs were cut from stems and branches by gnawing. A random sample of 400 twigs from one large cache revealed that twigs

ranged from 8 to 125 mm in length (75% 20 to 60 mm) and from 1 to 6 mm in diameter. *P. intermedius* may be unable to manipulate and carry larger twigs. Most twigs in caches were almost completely stripped of bark (Figure 1). Tooth marks indicated that bark was removed by gnawing with the incisors. The woody xylem was not eaten.

Plant species and their frequency of occurrence in the 65 caches were maple (*Acer rubrum* and *A. spicatum*) 43.1%; blueberry (*Vaccinium* sp.) 35.4%; Trembling Aspen (*Populus tremuloides*) 13.9%; Bearberry (*Arctostaphylos uva-ursi*) 12.3%; White Birch (*Betula papyrifera*) 12.3%; Sweetfern (*Myrica asplenifolia*) 12.3%; cherry (*Prunus* sp.) 9.2%; Northern Bush Honeysuckle (*Diervilla lonicera*) 9.2%; Juneberry (*Amelanchier arborea*, *A. sanguinea*) 7.7%; Green Alder (*Alnus crispa*) 7.7%; Beaked Hazel (*Corylus cornuta*) 6.2%; Round-leaf Dogwood (*Cornus rugosa*) 3.1%; Sweetgale (*Myrica gale*) 1.5%; Leatherleaf (*Chamaedaphne calyculata*) 1.5%; and honeysuckle (*Lonicera* sp.) 1.5%. No coniferous species were found in twig caches.

My observations suggest that *P. intermedius* is opportunistic in gathering twigs. The relative abundance of various plant species in twig piles generally reflected their availability. The dominant shrubs in Heather Vole habitats in Quetico were Red Maple, Mountain Maple, and species of heather. Although branches of Trembling Aspen and White Birch trees were beyond the reach of Heather Voles even with deep snow on the ground, *P. intermedius* utilized recent blowdowns of these trees. All caches of Trembling Aspen and White Birch that I collected were situated near or under recent blowdowns. The smaller branches and stems of these fallen trees were heavily gnawed and girdled.

The absence of conifers in caches, however, is curious. Jack Pine, Balsam Fir and White Spruce were common in Heather Vole habitats and numerous blowdowns of conifers were present in forests. Inadequate nutrients or the presence of unpalatable resins (Bryant and Kuropat 1980) may make the bark of conifers undesirable to *P. intermedius*. Previous observations of *P. intermedius* suggested that its winter diet was restricted to the bark of willow, birch, and species of Ericaceae (Shaw 1924; Foster 1961; Nagorsen 1982). However, these studies were in alpine or subarctic habitats that supported few species of broad-leaved woody plants. My results demonstrate that the Heather Vole uses a wide range of woody plants for winter food in mixed forests of the Great Lakes - St. Lawrence Forest Region, where there is a diversity of broad-leaved shrub and tree species.

Bark-gnawing during winter has been reported for

several vole species (Spencer 1984), but *P. intermedius* and the arboreal Red Tree Vole (*Arborimus longicaudus*) are the only North American voles that cut and store twigs in food caches. Energy costs and risks of predation from this activity are presumably offset by some benefits to *P. intermedius*. If winter caches are located near nests, they would provide an accessible food supply during inclement winter weather. Some of the large twig piles that I found represent substantial food reserves for a single Heather Vole and these caches may have been constructed to hoard food resources. Alternately, large twig piles may have been feeding sites where twigs were deposited repeatedly throughout the winter. The construction of twig caches by *P. intermedius* has not been observed in the wild and nothing is known about the phenology of twig caching or the number of voles that may utilize a cache.

Most species of voles are social during winter, and communal nesting and even food sharing occur in some species (West and Dublin 1984). Because clumped food resources are conducive to voles' forming social groups, *P. intermedius* would be expected to demonstrate some degree of sociality in winter. However, the social biology of the Heather Vole is unknown. Winter caching behaviour and its role in the social biology of *P. intermedius* should be explored in future studies.

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Literature Cited

- Bryant, J. P. and P. J. Kuropat. 1980. Selection of winter forage by subarctic browsing vertebrates: the role of plant chemistry. *Annual Review of Ecology and Systematics* 11: 261-285.
- Foster, J. B. 1961. Life history of the phenacomys vole. *Journal of Mammalogy* 42: 181-198.
- Johnson, M. L. 1973. Characters of the heather vole, *Phenacomys*, and the red tree vole, *Arborimus*. *Journal of Mammalogy* 54: 239-244.
- Miller, G. S., Jr. 1897. Notes on the mammals of Ontario. *Proceedings of the Boston Society of Natural History* 28: 1-44.

- Nagorsen, D. W.** 1982. Small mammals from the Sutton Ridges, northern Ontario. *Ontario Field Biologist* 36: 79-88.
- Nagorsen, D. W., and R. L. Peterson.** 1981. Distribution, abundance and species diversity of small mammals in Quetico Provincial Park, Ontario. *Le Naturaliste canadien* 108: 209-218.
- Racey, K.** 1936. Notes on some mammals of the Chilcotin Region, British Columbia. *Canadian Field-Naturalist* 50: 15-21.
- Shaw, W. T.** 1924. Alpine life of the heather vole (*Phenacomys olympicus*). *Journal of Mammalogy* 5: 12-15.
- Spencer, A. W.** 1984. Food habits, grazing activities, and reproductive development of long-tailed voles, *Microtus longicaudus* (Merriam) in relation to snow cover in the mountains of Colorado. Pp. 67-90 in *Winter ecology of small mammals*. Edited by J. F. Merritt. Carnegie Museum of Natural History, Special Publication No. 10.
- West, S. D., and H. T. Dublin.** 1984. Behavioral strategies of small mammals under winter conditions: solitary or social? Pp. 293-299 in *Winter ecology of small mammals*. Edited by J. F. Merritt. Carnegie Museum of Natural History, Special Publication No. 10.

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Notes

Winter Records of Bald Eagles, *Haliaeetus leucocephalus*, in Interior Alaska

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Ritchie, Robert J., and Robert E. Ambrose. 1987. Winter records of Bald Eagles, *Haliaeetus leucocephalus*, in interior Alaska. *Canadian Field-Naturalist* 101(1): 86-87.

Adult Bald Eagles were recorded on winter surveys in 1979, 1980, and in 1982-1984 on the Tanana River (64°N, 145°W). This is 400 km north of their normal winter range. Possible reasons for this regular and surprising winter occurrence are prey concentrations and a sizeable breeding population of eagles, some of which may benefit from wintering there and nesting earlier than migrants.

Key Words: Bald Eagle, *Haliaeetus leucocephalus*, Alaska, distribution, winter.

The bays and river mouths of southcentral Alaska (61°N) are generally considered the northern limit in the continuous range of the Bald Eagle (*Haliaeetus leucocephalus*) in North America (Figure 1, adapted from Steenhof (1978)). Nearly complete ice coverage of inland waterbodies north of the Alaska Range and an extension of sea ice north of the Alaska Peninsula severely limit possibilities for Bald Eagles to winter above 61°N. Gabrielson and Lincoln (1959) suggested that Bald Eagles from interior Alaska moved to the Alaskan coast or farther in winter.

However, we have regularly observed and recorded Bald Eagles 400 km north of their normal winter range. In January 1979 we located eight adult Bald Eagles on the Tanana River or its tributaries between Fairbanks and Delta (Figure 1). We also recorded three adults in the area during each winter aerial survey of 1980, 1982 and 1983, and five Bald Eagles in 1984. Approximately 30 to 50 km of open water existed in this area each year.

Two factors may account for this regular but surprising winter occurrence. First, the region has one of the most dense Bald Eagle breeding populations in the interior of Alaska (Ritchie 1981) and some wintering Bald Eagles apparently belong to this population. Observations at two nests for the past four years revealed that birds roosted near nests in winter and began incubation as much as one month earlier than migrant Bald Eagles in the same area. Overwintering on the breeding grounds may give birds a competitive advantage in securing territories and initiating breeding.

Second, open water along the Tanana River attracts and concentrates certain prey species, especially spawning salmon *Oncorhynchus* sp., Mallard *Anas platyrhynchos*, and Common Merganser, *Mergus merganser*. All have been identified in prey remains at Bald Eagle nest sites in the area (Ritchie 1981). The extent of open water and abundance of salmon and waterfowl may be critical. Although smaller open water areas on the Toklat River have regularly attracted mallards and are used for spawning by salmon (Sheldon 1909; P. Valkenburg, (personal communication), we know of no Bald Eagle observations in midwinter at this location.

Records of Bald Eagles overwintering in northern boreal forests are rare. D. Whitfield, University of Alberta (personal communication) has recorded a few near Calgary, Alberta, as well as December sightings on the Saskatchewan River. Preble (1908) recorded Bald Eagles in winter near Great Slave Lake, Northwest Territories. Our sightings near Delta (64°05'N, 145°W) are the northernmost reported in winter in North America.

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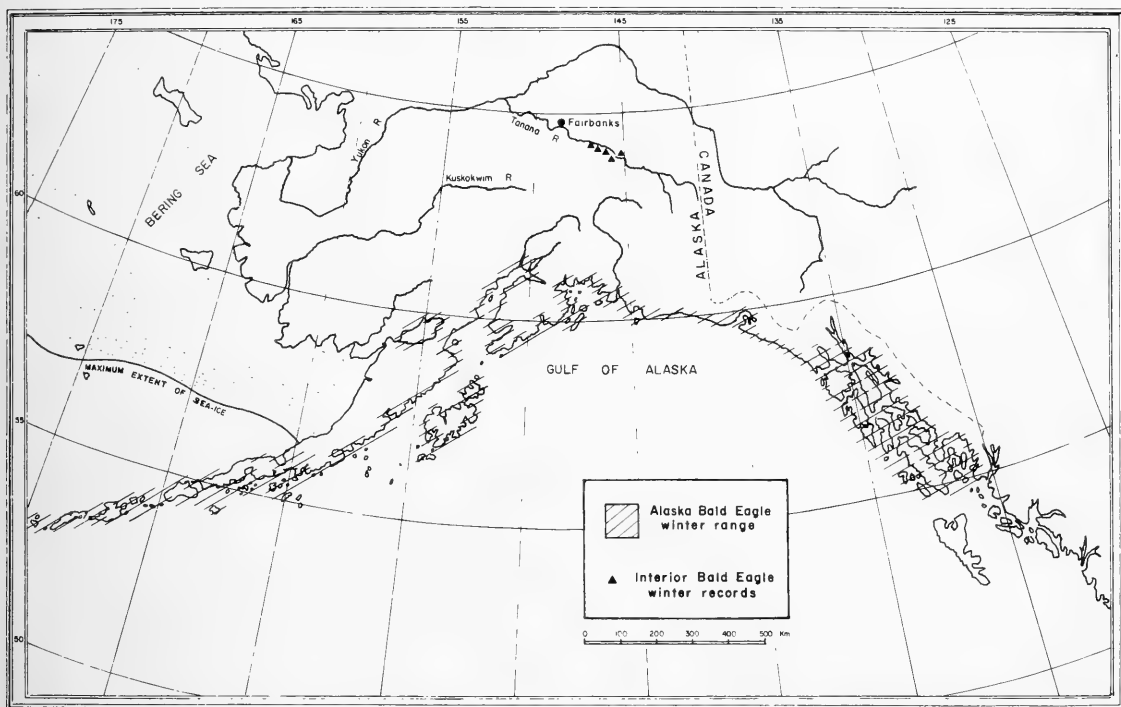


FIGURE 1. Bald Eagle winter distribution in Alaska (adapted from Steenhof (1978)) and interior Alaska records.

MacDonald, University of Alaska, Fairbanks, kindly provided access to unpublished records.

Literature Cited

- Gabrielson, I. N., and F. C. Lincoln. 1959. The birds of Alaska. Stackpole Co., Harrisburg, Pennsylvania. 932 pp.
- Preble, E. A. 1908. A biological investigation of the Athabaska-Mackenzie Region. North American Fauna Number 27. 574 pp.
- Ritchie, R. J. 1981. Investigations of Bald Eagles, Tanana River, Alaska, 1977-80. Pp. 55-67 in Proceedings of a symposium and workshop on raptor management and

biology in Alaska and western Canada. Edited by W. N. Ladd and P. F. Schempf. United States Fish and Wildlife Service, Anchorage, Alaska. 335 pp.

Sheldon, C. 1909. List of birds observed on the upper Toklat River near Mt. McKinley, Alaska, 1907-1908. Auk 26: 66-70.

Steenhof, K. 1978. Management of wintering bald eagles. United States Department of the Interior, Fish and Wildlife Service. 60 pp.

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Status and Distribution of Two Species of Cottontail Rabbits, *Sylvilagus transitionalis* and *S. floridanus*, in Southeastern Massachusetts

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Hoff, James G. 1987. Status and distribution of two species of cottontail rabbits, *Sylvilagus transitionalis* and *S. floridanus*, in southeastern Massachusetts. *Canadian Field-Naturalist* 101(1): 88–89.

In a sample of 247 *Sylvilagus* spp. from southeastern Massachusetts, 18 (7%) were the indigenous New England Cottontail.

Key Words: Cottontail rabbit, *Sylvilagus floridanus*, New England Cottontail, *Sylvilagus transitionalis*, population status, Massachusetts.

The early faunal studies of Bangs (1894) and Nelson (1909) indicated that the New England Cottontail, *Sylvilagus transitionalis*, was the only member of its genus indigenous to New England. Later, Goodwin (1935) documented the extension of the range of the Eastern Cottontail, *S. floridanus*, from southeastern New York to northwestern Connecticut, and subsequent investigations (Hosley 1942) revealed the widespread occurrence of *S. floridanus* throughout most of Connecticut.

Johnston (1972) reviewed the history of the Eastern Cottontail in southern New England. He reported that prior to 1930 the Eastern Cottontail was known in Massachusetts only from the island of Nantucket. Massachusetts was the first of the three southern New England states to stock introduced Eastern Cottontails; it released, stocked, and distributed more cottontails than the other two states. Many of these early releases and transfer points were in Bristol and Plymouth counties in southeastern Massachusetts. The first post-release records of the Eastern Cottontail for the mainland of Massachusetts are from 1930–1949 and they indicate that seven specimens were collected from central and western Massachusetts. Massachusetts Fish and Game records for southeastern Massachusetts are for the period 1950–1969 and are apparently the only records of the Eastern Cottontail for southeastern Massachusetts (Johnston 1972). A total of 37% of the rabbits collected in these two counties were the indigenous species.

In this study, 247 road-kill adult cottontails were collected from two-lane blacktop roads. Collections were made yearly from February through April over an eleven year period from 1970–1981. Habitat notes were made at the collection site. Identification of the specimens was first determined by pelage characteristics (Nelson 1909; Chandler 1952). The skull characteristics reported by Nelson (1909) and

Chandler (1952) and the presence or absence of the tympanic process reported by Hinderstein (1969) were also used. Chapman and Stauffer (1979) have recently synthesized morphological differences for these species.

Eighteen of the 247 rabbits collected (7%) were the indigenous New England Cottontails. The dramatic decline in the New England Cottontail population from 37 to 7 percent in approximately 20 years is not unique to southeastern Massachusetts. The decline seems to have occurred over most of the range wherever and whenever the New England Cottontail comes in contact with the Eastern Cottontail (Chapman and Stauffer 1979). This imminent demise has led the United States Fish and Wildlife Service to place the New England Cottontail on review to establish its threatened or endangered status. Chapman and Stauffer (1979) recommend that populations of *Sylvilagus transitionalis* be listed in a category such as special concern.

Chapman et al. (1977) reviewed habitat selection by these species. They found an inherent difference in the regions that contained New England Cottontails. The most obvious factor was the colder climate and its characteristic flora. The fact that the New England Cottontail was well adapted to cold climates was supported by the high condition and body fat indices and low adrenal index during winter. They concluded that high temperatures and associated phenomena constituted a stress on the New England Cottontail. In a status review of the species, Chapman and Stauffer (1979) concluded that the restricted habitat requirements are usually associated with dense cover and conifers. The preference of the New England Cottontail for higher elevation was shown by plotting latitude and elevation for records throughout much of the range.

In reviewing the habitat notes for this study, I found that seven New England Cottontails were collected

within 200 m of commercial cranberry bogs. These collection sites have in common the lower temperature one would find at higher elevations as well as the presence of alders that border most of the cranberry bogs. It would appear that *S. transitionalis* has retreated into high-altitude habitats in much of its range. In southeastern Massachusetts where maximum relief is less than 100 m, the species has retreated to the more cold, wet patches.

Literature Cited

- Bangs, O.** 1894. The geographical distribution of the eastern races of the cotton-tail (*Lepus sylvaticus* Bach.) with a description of a new subspecies, and with notes on the distribution of the northern hare (*Lepus americanus* Erxl.) in the east. Proceedings of the Boston Natural History Society 26: 404-414.
- Chandler, E. H.** 1952. The geographical and ecological distribution of Massachusetts cottontails. M.Sc. thesis, University of Massachusetts, Amherst. 52 pp.
- Chapman, J. A., A. L. Harman, and D. E. Samuel.** 1977. Reproduction and physiological cycles in the cottontail complex in western Maryland and nearby West Virginia. Wildlife Monograph #56. 73 pp.
- Chapman, J. A., and J. R. Stauffer, Jr.** 1979. The status and distribution of the New England Cottontail. Pp. 973-983 in Proceedings of the world lagomorph conference, Guelph, Ontario.
- Goodwin, G. G.** 1935. The mammals of Connecticut. Connecticut Geological and Natural History Survey Bulletin 52. Hartford. 221 pp.
- Hinderstein, C. L.** 1969. A comparative study of cranial characters of two cottontails *Sylvilagus floridanus* and *Sylvilagus transitionalis* (Leporidae: Mammalia) in a region of sympatry (Northern New Jersey, Eastern New York, and Connecticut). M.Sc. thesis, Queens College, Flushing, New York. 119 pp.
- Hosley, N. W., Editor.** 1942. The cottontail rabbits in Connecticut. State Geological and Natural History Survey Bulletin 65: 1-197.
- Johnston, J. E.** 1972. Identification and distribution of cottontail rabbits in southern New England. M.Sc. thesis, University of Connecticut, Storrs. 70 pp.
- Nelson, E. W.** 1909. The rabbits of North America. United States Department of Agriculture, North American Fauna 9. 314 pp.

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The Effect of Water Level Fluctuations on Muskrat, *Ondatra zibethicus*, Predation by Mink, *Mustela vison*

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A study of Mink (*Mustela vison*) food habits and movements was undertaken incidental to studies on Muskrat (*Ondatra zibethicus*) at Luther Marsh, Ontario, 1978-80. In the summers of 1978 and 1979, when water level was low, Mink went deep into the marsh and preyed on aquatic birds and Muskrats. In 1980, with high water levels, Mink movements appeared to be restricted to the marshland edge and they preyed mostly on crayfish and Meadow Voles (*Microtus pennsylvanicus*). The 1979-80 winter scat analysis indicated that Muskrats were the major Mink food item in frequency and volume.

Key Words: Mink, *Mustela vison*, Muskrat, *Ondatra zibethicus*, waterfowl, predation, food habits, Ontario.

Mink (*Mustela vison*) predation can be an important depressive factor on Muskrat (*Ondatra zibethicus*) populations (Errington 1954). The choice of prey by Mink, however, depends not only upon the abundance of the prey species but also on the vulnerability (Sealander 1942; Waller 1962; Gerell 1971). During studies of Muskrat populations at

Luther Marsh, Ontario (43° 56' N, 80° 26' W), from 1978 to 1980 (McDonnell and Gilbert 1981; Proulx and Gilbert 1983), observations on Mink food habits and movements relative to water level fluctuations were gathered. These are presented here.

Mink scats were collected in East Bay in the summers of 1978, 1979 and 1980, and during winter

1979-80, and in Western Shore, Teal Bay and Creek in the summers of 1979 and 1980. Mink movements were studied in East Bay in the summers of 1979 and 1980. These habitats have been described by Proulx and Gilbert (1983). In 1978, Mink scats were classified as summer (collected in July-August) or fall (September-November). In 1979 and 1980, Mink scats were classified as summer (July-October) or winter (January-February). They were analyzed according to Adorjan and Kolenosky (1969) and Moore et al. (1974). Identification of the remains was done according to Chandler (1916), Day (1966) and Brunner and Coman (1974), and by comparison with museum specimens. In 1978, statistical comparisons of the frequencies (chi-square test) and mean volume per scat (Student's t-test) of remains between the summer and fall were made. In 1979 and 1980, because of small sample sizes, remains were not statistically tested. Trapping activities were oriented towards an optimum sampling of Muskrat populations. Mink that entered the traps were those visiting Muskrat breeding grounds and it was assumed that the capture success from year to year was indicative of the intensity of utilization of Muskrat habitat by Mink. Trapping procedure was described by Proulx and Gilbert (1983).

Muskrat remains increased in frequency and volume from summer to fall 1978, but the difference was not significant ($p > 0.01$; Table 1). However, from one season to another, the waterfowl remains significantly ($p < 0.01$) decreased in frequency, and the frog remains increased in frequency and volume ($p < 0.01$; Table 1). Muskrat remains represented 17.1% of the total volume of 1979 summer scats but were absent in 1980 summer scats. Meadow Voles (*Microtus pennsylvanicus*) were absent in 1979 summer scats but represented the second most important Mink food item, after crayfish, in summer 1980 (Table 1). Bird remains were more important in frequency and volume in summer 1980 (Table 1). In summer 1979, Mink scats were collected deep in the marsh, and eight Mink (three adults and five juveniles) were captured in East Bay. Before late July low water levels and extensive dry-outs in 1979 (see Proulx and Gilbert 1983), only one capture occurred on 5 July, near the upland. From 23 July to 22 September 1979, however, seven captures and seven recaptures occurred in areas where Muskrats concentrated their building and feeding activities (see Proulx and Gilbert 1983). In summer 1980, Mink scats were found at the edge of the marshland. Only one juvenile was captured in East Bay, at a Muskrat house built in proximity to the marshland border.

Rodent remains were predominant in the eight

1979-80 winter scats and Muskrat remains were found in 37.5% of the scats, representing 24.0% of the total volume of scats (Table 1).

From May to September, major water level declines of 62.5 cm and 72 cm were recorded in 1978 and 1979, respectively (McDonnell 1979; Proulx 1981). In 1978 and 1979, as mud became exposed (approximately the end of July), increased Mink activity in the marsh was suggested by numerous tracks and fresh scats, and by the presence of predated Muskrat kits. Also, the 1978 summer scat analysis indicated that Muskrats constituted the single most important Mink food item in July and August. This finding tends to agree with Errington (1943), who suggested that Muskrats are more vulnerable to predation when their habitat has been exposed to drought. The fall increase in Muskrat and frog consumption by Mink may be a result of their greater availability (Hamilton 1940; Gerell 1971; Gilbert and Nancekivell 1982), since waterfowl are less vulnerable in fall than during the breeding season, and less abundant with the beginning of their migratory movements.

When combined with the Mink capture data, the 1979 and 1980 scat analyses, despite their small sample size, suggest that Mink hunting grounds changed from year to year and that water levels had an effect on Muskrat predation by Mink. In the summers of 1978 and 1979, with low water levels, Mink were going into marsh habitats and scat analyses indicated prey consisted mostly of aquatic birds and Muskrats. In 1980, however, with high water levels, Mink movements appeared to be restricted to the edges of the marsh and prey primarily consisted of crayfish and Meadow Voles found in areas adjacent to or at the border of marshlands. Mink predation on Muskrats seems to be more common during winter than in other seasons (Yeager 1943; Wilson 1954; Errington 1961). The 1979-80 winter scat analysis indicated that Muskrats were the most important Mink food item in frequency and volume. Mink tracks covered East Bay and Mink travelled from one Muskrat house to another, some of which were opened.

The data gathered in the summers of 1978 and 1979 and in winter 1979-80, when compared to those of summer 1980, agree with Errington (1961), who concluded that Mink seldom go into the deeper portions of marshes until freeze-up or unless drought makes the deeper tracts more accessible. Undoubtedly, the creation of an even interspersed vegetation and open water areas (Proulx and Gilbert 1983) and the reduction of extensive dry-outs through habitat manipulation would help to reduce the intensity of Muskrat predation by Mink.

TABLE 1. Frequencies and relative volumes (%) of food items by season in Mink scats collected from Luther Marsh study areas.

	Summer 1978 N = 93		Fall 1978 N = 61		Summer 1979 N = 81		Winter 1979-80 N = 82		Summer 1980 N = 73	
	Frequency (%)	Volume	Frequency (%)	Volume	Frequency (%)	Volume	Frequency (%)	Volume	Frequency (%)	Volume
MAMMALIA										
<i>Microtus pennsylvanicus</i>	19 (20.4)	15.5	8 (13.1)***	10.8***	—	—	2 (25.0)	5.3	3 (42.8)	9.0
<i>Ondatra zibethicus</i>	30 (32.3)	32.7	25 (41.0)***	39.0***	1 (12.5)	17.1	3 (37.5)	24.0	—	—
<i>Peromyscus</i> sp.	1 (1.0)	0.1	—	—	—	—	—	—	—	—
<i>Blarina brevicauda</i>	5 (5.4)	3.5	2 (3.3)	2.8	—	—	—	—	—	—
<i>Sorex</i> sp.	1 (1.0)	0.1	—	—	—	—	—	—	—	—
<i>Mustela vison</i>	1 (1.0)	0.1	5 (8.2)	2.8	—	—	—	—	—	—
Unknown	1 (1.0)	0.1	1 (1.6)	0.1	—	—	—	—	—	—
TOTAL	58 (62.1)	52.1	41 (67.2)***	55.5***	1 (12.5)	17.1	5 (62.5)	29.3	3 (42.8)	9.0
AVES										
Anseriformes	23 (24.7)	17.4	5 (8.2)*	10.8***	2 (25.0)	4.0	2 (25.0)	7.6	1 (14.3)	2.7
Passeriformes	5 (5.4)	2.3	—	—	3 (37.5)	10.2	—	—	—	—
Charadriiformes and Gruiformes	6 (6.5)	6.9	—	—	1 (12.5)	2.8	—	—	—	—
Unknown	5 (5.4)	0.8	4 (6.6)	0.6	1 (12.5)	11.4	—	—	—	—
TOTAL	39 (42)	27.4	9 (14.8)*	11.4**	7 (87.5)	28.4	2 (25.0)	7.6	1 (14.3)	2.7
REPTILIA AND AMPHIBIA										
Snake	2 (2.2)	1.6	—	—	1 (12.5)	0.3	1 (12.5)	4.7	—	—
Frog	5 (5.4)	1.3	17 (27.9)*	16.1**	—	—	—	—	—	—
ARTHROPODA										
Crayfish	24 (25.8)	12.1	9 (14.8)***	4.5***	—	—	—	—	5 (71.4)	35.2
Insect	24 (25.8)	3.7	25 (41.0)***	6.3***	—	—	—	—	1 (14.3)	0.3
MISCELLANEOUS										
Fish	—	—	1 (1.6)	1.1	—	—	1 (12.5)	3.5	—	—
Vegetation	2 (2.2)	0.6	5 (8.2)	4.5	1 (12.5)	0.6	—	—	1 (14.3)	0.3
Eggshell	4 (4.3)	0.4	1 (1.6)	0.1	—	—	—	—	—	—
Snails and bivalves	11 (11.8)	0.8	4 (6.6)	0.5	—	—	—	—	—	—
Other	1 (1.1)	0.1	1 (1.6)	0.2	—	—	—	—	—	—

¹Six scats from East Bay, one from Teal Bay and one from Creek.²All scats from East Bay.³Three scats from East Bay and four from Western Shore.*Significant difference (chi-square test, $p < 0.01$) between summer and fall.**Significant difference in mean volume per scat (Student's t-test, $p < 0.01$) between summer and fall.***Difference not significant ($p > 0.01$).

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Literature Cited

- Adorjan, A. S., and G. B. Kolenosky.** 1969. A manual for the identification of hairs of selected Ontario mammals. Ontario Department of Lands and Forest Research Report (Wildlife) 90. 64 pp.
- Brunner, H., and B. J. Coman.** 1974. The identification of mammalian hair. Inkata Press, Melbourne. 16 pp.
- Chandler, A. C.** 1916. A study of the structure of feathers with reference to their taxonomic significance. *Zoology (California)* 13: 243-266.
- Day, M. G.** 1966. Identification of hair and feather remains in the gut of stoats and weasels. *Journal of Zoology* 148: 201-217.
- Errington, P. L.** 1943. An analysis of mink predation upon muskrats in north-central United States. Iowa State College of Agriculture Mechanical Arts Research Bulletin 320: 797-924.
- Errington, P. L.** 1954. The special responsiveness of minks to epizootics in muskrat populations. *Ecological Monographs* 24: 377-393.
- Errington, P. L.** 1961. Muskrats and marsh management. Wildlife Management Institute Publication. University of Nebraska Press. 183 pp.
- Gerell, R.** 1971. Distributional history, food habits, diel behaviour, territoriality, and population fluctuations of the mink *Mustela vison* Schreber in Sweden. Dissertation Zoological Institute, Lund 1971: 4 pp.
- Gilbert, F. F., and E. G. Nancekivell.** 1982. Food habits of mink (*Mustela vison*) and otter (*Lutra canadensis*) in northeastern Alberta. *Canadian Journal of Zoology* 60: 1282-1288.
- Hamilton, W. J., Jr.** 1940. The summer food of minks and raccoons on the Montezuma Marsh, New York. *Journal of Wildlife Management* 4: 80-84.
- McDonnell, J. A.** 1979. Behavioral responses of muskrats (*Ondatra zibethicus*) to water level fluctuations at Luther Marsh, Ontario. M.Sc. thesis, University of Guelph, Guelph, Ontario. 69 pp.
- McDonnell, J. A., and F. F. Gilbert.** 1981. The responses of muskrats (*Ondatra zibethicus*) to water level fluctuations at Luther Marsh, Ontario. Pp. 1027-1040 in *Worldwide furbearer conference proceedings. Edited by J. A. Chapman and D. Pursley.* R. R. Donnelly and Sons Co., Falls Church, Virginia.
- Moore, T. D., L. E. Spence, and C. E. Dug-nolle.** 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Wyoming Game and Fish Department Bulletin No. 14. 117 pp.
- Proulx, G.** 1981. Relationship between muskrat populations, vegetation and water level fluctuations and management considerations at Luther Marsh, Ontario. Ph.D. thesis, University of Guelph, Guelph, Ontario. 239 pp.
- Proulx, G., and F. F. Gilbert.** 1983. The ecology of the Muskrat, *Ondatra zibethicus*, at Luther Marsh, Ontario. *Canadian Field-Naturalist* 97: 377-390.
- Sealand, J. A.** 1942. Studies of trapped mink (*Mustela vison*) in southern Michigan. M.Sc. thesis, Michigan State College of Agriculture and Applied Science, East Lansing, Michigan. 94 pp.
- Waller, D. W.** 1962. Feeding behavior of minks at some Iowa marshes. M.Sc. thesis, Iowa State University, Ames, Iowa. 90 pp.
- Wilson, K. A.** 1954. The role of mink and otter as muskrat predators in Northeastern North Carolina. *Journal of Wildlife Management* 18: 199-207.
- Yeager, L. E.** 1943. Storing of muskrats and other foods by mink. *Journal of Mammalogy* 24: 100-101.

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Early Arrival Dates for Summering Tundra Swans, *Cygnus columbianus*, in Alaska

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Wilk, Randall J. 1987. Early arrival dates for summering Tundra Swans, *Cygnus columbianus*, in Alaska. *Canadian Field-Naturalist* 101(1): 93-94.

On 23 March 1983 and 15 March 1984 the first Tundra Swan, *Cygnus columbianus*, pairs were observed on their summering grounds on the northern Alaska Peninsula. These dates are the earliest recorded.

Key Words: Tundra Swan, *Cygnus columbianus*, Whistling Swan, *Cygnus buccinator*, Alaska, arrival dates, migration.

Spring arrival dates of Tundra Swans, *Cygnus columbianus*, have been reported in numerous bird studies in North America. Gavin (1947), Gabrielson and Lincoln (1959), Murie (1959), Barry and Kear (1972), Bellrose (1980), Lumsden (1975, 1984) and McLaren and McLaren (1984) are a cross-section of published literature and bibliographical references with Tundra Swan arrival dates. These sources include more than 25 locations in arctic and subarctic Alaska and Canada. I have found no published arrival dates, however, for Tundra Swans of the northern Alaska Peninsula (NAP). On 23 March 1983 and 15 March 1984 single Tundra Swan pairs were observed in open water on their traditional nesting areas on NAP. Former refuge manager J. T. Taylor made the 1983 observation on the Naknek River near Lake Camp, Katmai National Park and Preserve (58°40'N, 156°27'W). I made the 1984 observation during a flight midway between King Salmon (KS) (58°43'N, 156°45'W) and Egegik (58°13'N, 157°23'W). These observed arrival dates are at least two to four weeks earlier than those previously reported for other major summering swan populations in North America.

On NAP, Tundra Swans breed in the wet tundra lowlands adjoining Bristol Bay and the Bering Sea, and in scattered suitable habitats along the rugged Pacific coast (U. S. Fish and Wildlife Service 1983; Wilk 1985). These swans migrate along a discrete Pacific coast corridor to winter between San Francisco Bay and coastal British Columbia (Palmer 1976; Bellrose 1980; U. S. Fish and Wildlife Service 1983). This westernmost corridor is perhaps the shortest one-way distance for any of the migrating Pacific Flyway Tundra Swans (Bellrose 1980: 96). Bellrose (1980: 99) stated that these swans leave their California wintering areas as early as mid-February. Hansen et al. (1971: 33) reported that thousands of Tundra Swans, along with a few Trumpeter Swans, *Cygnus buccinator*, have arrived by 20 March on the Copper River Delta, Alaska (670 km NE of KS)

enroute to their Bering Sea coast nesting grounds. Palmer (1976: 81) presumed that these swans arrived comparatively early at these nesting areas. Considering the Tundra Swans's ability to obtain fast ground speeds during migration, travelling long distances day and night with infrequent rest stops (Sladen et al 1969; Bellrose 1980), March arrival dates on NAP are plausible.

Tundra Swans have been observed as early as 7 March (1981) and as late as 15 April (1978) near King Salmon by R. Russel, a state fishery biologist and knowledgeable birder (R. Russel, unpublished data). The records were admittedly from casual observations and may not reflect the earliest arrivals for each year. Nonetheless, the mean arrival date for the eight consecutive-year period during 1975-1982 was 30 March. Further substantiation of March arrival dates was provided by J. Prestage, a 20-year resident of KS. Prestage has observed swans on the Naknek River (a major spring staging area for NAP swans Wilk 1985,) about 15 or 16 March in most years of normal weather, and as early as 7 or 8 March in mild years (J. Prestage, personal communication). Spring aerial waterbird surveys conducted by the U. S. Fish and Wildlife Service over the Naknek River showed a rapid, substantial build-up of wildfowl numbers, including peak counts of 3000 Tundra Swans by 24 April; many of these swans nest near the river (Wilk 1985). This date is earlier than most first arrivals reported in the literature. The above dates and chronology of events are also supportive of March arrival dates for NAP swans.

The Alaska Peninsula's great geographical extension (153°20'W to 163°20'W and 54°50'N to 59°20'N), diverse physiography, and narrow land mass (175 km across at its base, and < 25 km across at its southern terminus) influenced by the Bering Sea foster a unique polar maritime climate with highly variable weather patterns that are markedly different from one area to another (Bristol Bay Coastal

Resources Service Area Board 1984). Climate in the northern areas is continental, with weather extremes and generally drier conditions (north of the Aleutian Range), while the south has moderating, windier conditions with higher precipitation (Aleutian maritime).

Unlike Tundra Swan nesting areas farther north, snow cover is generally absent on the peninsula's lowlands in March, and quickly-moderating spring conditions cause comparatively rapid changes in local environments. In the southern, Pacific northwest wintering grounds, mild late-winter weather probably influences the chronology of swan migration, as the western population migrates earlier and more swiftly than the eastern populations (Bellrose 1980). The unique combination of moderate climate in the wintering areas, temperate conditions of the northern breeding areas, and the shorter direct migration favour early arrival of Tundra Swans in the northern Alaska Peninsula.

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Literature Cited

- Barry, T. W., and J. Kear. 1972. A bibliography of the swans. Canadian Wildlife Service, Edmonton, Alberta. 181 pp.
- Bellrose, F. C. 1980. Ducks, geese and swans of North America. Third edition. Stackpole Company, Harrisburg, Pennsylvania. 544 pp.
- Bristol Bay Coastal Resources Service Area Board. 1984. Bristol Bay coastal management program I: resource inventory. Bristol Bay Native Association, Dillingham, Alaska. 21 pp.
- Gabrielson, I. N., and F. C. Lincoln. 1959. The birds of Alaska. Stackpole Company, Harrisburg, Pennsylvania. 922 pp.

- Gavin, A. 1947. Birds of Perry River District, Northwest Territories. Wilson Bulletin 59: 195-203.
- Hansen, H. A., P. E. K. Shepherd, J. G. King, and W. A. Troyer. 1971. The Trumpeter Swan in Alaska. Wildlife Monograph 26. 83 pp.
- Lumsden, H. G. 1975. The Whistling Swan in James Bay and the southern region of Hudson Bay. Arctic 28: 194-200.
- Lumsden, H. G. 1984. The pre-settlement breeding distribution of Trumpeter, *Cygnus buccinator*, and Tundra Swans, *C. columbianus*, in eastern Canada. Canadian Field-Naturalist 98: 415-424.
- McLaren, M. A., and P. L. McLaren. 1984. Tundra Swans in northeastern Keewatin District, N.W.T. Wilson Bulletin 96: 6-11.
- Murie, O. J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. North American Fauna 64. U. S. Government Printing Office, Washington, D.C. 364 pp.
- Palmer, R. S., Editor. 1976. Handbook of North American birds II, Part 1. Yale University Press, New Haven, Connecticut. 521 pp.
- Sladen, W. J. L., W. W. H. Gunn, and W. W. Cochran. 1969. Studies on the migrations of the Whistling Swan, 1969. Pp. 231-244 in Proceedings of the world conference on bird hazards to aircraft. Queens University, Kingston, Ontario.
- U. S. Fish and Wildlife Service. 1983. Pacific Flyway management plan for the western population of Whistling Swans. U. S. Fish and Wildlife Service, Portland, Oregon. 27 pp.
- Wilk, R. J. 1985. [Abstract]. Tundra Swan aerial survey on the northern Alaska Peninsula. Proceedings of the Alaska bird conference and workshop 1: 8. U. S. Fish and Wildlife Service, Anchorage, Alaska.

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Addendum

Subsequent to the revision of this paper, first-observed arrival dates for 1985 and 1986 near KS were 29 and 14 March, respectively.

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Responses of Three Prairie Ground Squirrel Species, *Spermophilus franklinii*, *S. richardsonii*, and *S. tridecemlineatus*, to Duck Eggs

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Sargeant, Alan B., Marsha A. Sovada, and Raymond J. Greenwood. 1987. Responses of three prairie ground squirrel species, *Spermophilus franklinii*, *S. richardsonii*, and *S. tridecemlineatus*, to duck eggs. *Canadian Field-Naturalist* 101(1): 95-97.

Franklin's Ground Squirrels (*Spermophilus franklinii*) preyed on eggs in 29 of 30 tests in which they were exposed to two Mallard (*Anas platyrhynchos*) or two Blue-winged Teal (*A. discors*) eggs and their discovery of eggs was confirmed. No Richardson's (*S. richardsonii*) or Thirteen-lined (*S. tridecemlineatus*) ground squirrels preyed on eggs in 104 and 54 similar tests, respectively. Franklin's Ground Squirrels exposed to clutches of six duck eggs placed in simulated nests preyed on all such clutches. Predation on simulated nests began soon after eggs were discovered, but predation of all eggs often took more than one day to complete.

Key Words: Predation, ground squirrels, *Spermophilus franklinii*, *S. richardsonii*, *S. tridecemlineatus*, duck eggs, Mallard, *Anas platyrhynchos*, Blue-winged Teal, *Anas discors*.

Predation on eggs is a major factor affecting duck nesting success in the prairie pothole region of North America (Cowardin and Johnson 1979; Cowardin et al. 1983a, 1983b). Predation is especially severe on duck species that nest in untilled uplands (Higgins 1977; Cowardin et al. 1983b), areas also preferred by ground squirrels (*Spermophilus* spp.) (Jones et al. 1983). Several species of ground squirrels prey on bird eggs (Errington and Hamerstrom 1937; Horn 1938; Stanton 1944; Sows 1948), but of the three species that occur in the prairie pothole region (Hall 1981), only the Franklin's Ground Squirrel (*Spermophilus franklinii*) has been identified as a predator of duck eggs (Bennett 1938; Sows 1948, 1955; Sargeant and Arnold 1984). Data are lacking on responses of Richardson's (*S. richardsonii*) and Thirteen-lined (*S. tridecemlineatus*) ground squirrels to duck eggs. This paper compares the responses of free-ranging Franklin's, Richardson's, and Thirteen-lined ground squirrels to duck eggs.

Study Areas and Methods

Field tests were conducted during May-August 1983 near the towns of Jamestown (47°00'N, 99°00'W) and Stanley (48°36'N, 102°24'W), North Dakota, and Gravelbourg (50°13'N, 106°37'W) and Hanley (51°39'N, 106°24'W), Saskatchewan. Two-egg tests were conducted to measure responses of the three species of ground squirrels to large (Mallard, *Anas platyrhynchos*) or small (Blue-winged Teal, *A. discors*) duck eggs. In each test two Mallard or two Blue-winged Teal eggs were placed at a site (e.g. near pathway, by burrow) where they were likely to be encountered by the desired species of ground squirrel. Tests were initiated throughout the day but

terminated by evening. Simulated-nest tests were conducted to measure ground squirrel treatment of clutches of eggs in nests. In each of these tests ground squirrels were exposed to simulated duck nests consisting of a salvaged duck nest and six Mallard or six Blue-winged Teal eggs. Simulated-nest tests were monitored for up to five days, but the nests were covered at night with a hood to reduce interference by nocturnal predators (ground squirrels are diurnal) (Choromanski-Norris 1983; Jones et al. 1983).

Ground squirrel response to eggs in both types of tests was monitored by observation, by use of 8-mm time-lapse movie cameras (15- or 30-second photo intervals), or both. Egg status was generally checked one to three times each day. A test was considered usable if a ground squirrel made visual or physical contact with the eggs and the eggs remained available to the ground squirrel for at least 1 hour afterward, or if one or more eggs was preyed on by a ground squirrel. Opening or removal of one or more eggs by a ground squirrel constituted predation. No more than one test of each type was conducted for each ground squirrel species at a test site. At simulated nests, ground squirrel appearances separated by absences of 10 minutes or less on the film record were considered part of the same visit; appearances over 10 minutes apart were considered separate visits.

Results

Two-egg tests

Results were obtained from 188 usable two-egg tests (Table 1). Franklin's Ground Squirrels preyed on eggs in all but one of 30 tests in which they were involved. Predation began within two minutes after eggs were discovered in 25 of 28 tests for which

TABLE 1. Responses by three species of ground squirrels to placements of two Mallard or two Blue-winged Teal eggs in natural settings in North Dakota and Saskatchewan.

	Total tests ¹ (N)	Tests with predation (N)	(%)
Franklin's Ground Squirrel			
Mallard eggs	27	26	96
Blue-winged Teal eggs	3	3	100
Total	30	29	97
Richardson's Ground Squirrel			
Mallard eggs	58	0	0
Blue-winged Teal eggs	46	0	0
Total	104	0	0
Thirteen-lined Ground Squirrel			
Mallard eggs	28	0	0
Blue-winged Teal eggs	26	0	0
Total	54	0	0

¹Includes only tests in which ground squirrel awareness of eggs was confirmed. Percentages of tests in each area were Franklin's Ground Squirrel (50% Jamestown, North Dakota; 50% Hanley, Saskatchewan), Richardson's Ground Squirrel (39% Jamestown, North Dakota; 38% Gravelbourg, Saskatchewan; 22% Stanley, North Dakota), and Thirteen-lined Ground Squirrel (85% Jamestown, North Dakota; 9% Stanley, North Dakota; 6% Hanley, Saskatchewan).

response times were known precisely. In two of the three tests in which predation began later (0.4-9.9 hours), initial discovery of eggs was by a juvenile ground squirrel and predation began within two minutes after arrival of an adult. In the test in which no predation occurred, the eggs appeared to have been discovered solely by a juvenile.

No predation occurred in 104 tests involving Richardson's Ground Squirrels and in 54 tests involving Thirteen-lined Ground Squirrels. Exposure time after discovery of eggs by these species averaged 2.2 (range 1.0 to 12.0, SD = 1.9) and 3.5 (range 1.0 to 13.7, SD = 3.3) hours, respectively. Sniffing of eggs was the extent of interest shown by Richardson's and Thirteen-lined ground squirrels in all but two tests. In one test a Thirteen-lined Ground Squirrel rolled a Blue-winged Teal egg about 15 cm and in another test a Thirteen-lined Ground Squirrel put its teeth around a Blue-winged Teal egg but did not penetrate it.

Simulated nests

Tests with simulated nests were conducted only with Franklin's Ground Squirrels because the other species did not prey on eggs in the two-egg tests.

Franklin's Ground Squirrel predation on eggs in 16 simulated nests (14 Mallard and 2 Blue-winged Teal) was documented. Three tests had minor interference by American Crow (*Corvus brachyrhynchos*), Black-billed Magpie (*Pica pica*), or Striped Skunk (*Mephitis mephitis*), and five tests were terminated before all eggs were preyed on. No more than one adult ground squirrel visited a nest at a time, but in four tests, one or two juvenile ground squirrels were present.

In all tests, predation began on the day eggs were discovered. Eggs disappeared or were destroyed gradually. Up to 5 (\bar{x} = 2.2) days were required for complete destruction of a clutch. The number of photographed visits to nests by adult Franklin's Ground Squirrels per hour of exposure time (daytime only) after eggs were discovered averaged 0.3 (range 0.1 to 0.7, SD = 0.2); duration of the average visit was 4.1 (range 0.5 to 35.0, SD = 6.2) minutes. Some additional brief (< 30 seconds) visits by Franklin's Ground Squirrels apparently occurred because a few eggs were taken during periods when no predator was photographed. Visits by juvenile ground squirrels lasted up to 49 minutes.

Of the 78 eggs placed in the 13 simulated nests believed to have been depredated solely by Franklin's Ground Squirrels, 17% remained uneaten in nest bowls when tests were terminated, 32% were missing from nest bowls and could not be accounted for, and 51% were accounted for from portions of eggshells, or in three instances from whole eggs found away from nests. The missing eggs were presumably taken into burrows or hidden elsewhere because feeding trials with captive Franklin's Ground Squirrels revealed they eat little or no eggshell (A. B. Sargeant, unpublished data). We observed Franklin's Ground Squirrels pushing and rolling eggs, and the shell from one eaten egg was found in a burrow entrance.

Discussion

Our results show that Franklin's Ground Squirrels have a strong attraction to duck eggs. Predation nearly always began immediately after they discovered the eggs and with simulated nests, continued until all eggs were taken or until the test was terminated. In contrast, Thirteen-lined and Richardson's ground squirrels showed almost no interest in duck eggs. Thirteen-lined Ground Squirrels are carnivorous (Bridgwater and Penny 1966) and are known to prey on eggs of ground-nesting passerines (Lein 1968; Creighton 1971; Graul 1972). These ground squirrels are relatively small, however, generally weighing 100-200 g compared with about 300-500 g for both the Franklin's and Richardson's ground squirrels (Choromanski-Norris 1983; Jones et al. 1983). Thirteen-lined Ground Squirrels showed

interest in Blue-winged Teal eggs in two tests but had no interest in the much larger Mallard eggs. Their lack of interest in duck eggs likely is related to egg size and shell thickness. Richardson's Ground Squirrels appear large enough to open duck eggs, but the lack of evidence from this study as well as the absence of other studies implicating them in predation on bird eggs indicates they seldom eat eggs.

Franklin's Ground Squirrel predation on duck nests is apparently a solitary process involving infrequent visits and often taking several days to complete. Wild duck nests often contain up to twice as many eggs as our simulated nests and a hen is present throughout most of the incubation period (Bellrose 1976). The presence of additional eggs would extend the amount of time required to completely destroy a clutch beyond the one to five days that we observed, and the presence of a hen would likely further delay or possibly stop the predation.

Franklin's Ground Squirrels are most abundant in the tall-grass prairie and mixed forest fringe along the northeastern edge of the prairie pothole region, where they inhabit dense herbaceous or brushy cover. They are scarce or absent in the short-grass prairie western fringe (Sowls 1955; Hall 1981; Jones et al. 1983). Franklin's Ground Squirrels are not social animals and densities are generally less than 2.5 adults per hectare (Murie 1973), although up to 12 adults and juveniles per hectare have been reported (Sowls 1955). Recent findings (Choromanski-Norris 1983; Greenwood 1986) show that Franklin's Ground Squirrels thrive in fields of grasses and legumes commonly planted for nesting ducks in eastern portions of the prairie pothole region (Duebbert et al. 1981). Individual ground squirrels travel extensively in such habitats (Choromanski-Norris 1983). Our findings and those of Sowls (1955) suggest that concerns over the possible impact of this rodent on duck nesting success in such habitats are justified.

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Literature Cited

- Bellrose, F. C. 1976. Ducks, geese and swans of North America. Second edition. Stackpole Books, Harrisburg, Pennsylvania. 544 pp.
- Bennett, L. J. 1938. The Blue-winged Teal. Collegiate Press, Ames, Iowa. 144 pp.
- Bridgwater, D. D., and D. F. Penny. 1966. Predation by *Citellus tridecemlineatus* on other vertebrates. Journal of Mammalogy 47: 345-346.

- Choromanski-Norris, J. F. 1983. The ecology of the Franklin's Ground Squirrel in North Dakota. M.Sc. thesis, University of Missouri, Columbia, Missouri. 70 pp.
- Cowardin, L. M., and D. H. Johnson. 1979. Mathematics and Mallard management. Journal of Wildlife Management 43: 18-35.
- Cowardin, L. M., D. H. Johnson, A. M. Frank, and A. T. Klett. 1983a. Simulating results of management actions on Mallard production. Transactions of the North American Wildlife Conference 48: 257-272.
- Cowardin, L. M., A. B. Sargeant, and H. F. Duebbert. 1983b. Problems and potentials for prairie ducks. Naturalist 34: 4-11.
- Creighton, P. D. 1971. Nesting of the Lark Bunting in north-central Colorado. Technical Report 68. Grassland Biome, U.S. International Biological Program. 17 pp.
- Duebbert, H. F., E. T. Jacobson, K. F. Higgins, and E. B. Podoll. 1981. Establishment of seeded grasslands for wildlife habitat in the prairie pothole region. U.S. Fish and Wildlife Service Special Scientific Report 234. 21 pp.
- Errington, P. L., and F. N. Hamerstrom, Jr. 1937. The evaluation of nesting losses and juvenile mortality of the Ring-necked Pheasant. Journal of Wildlife Management 1: 3-20.
- Graul, W. D. 1972. Breeding biology of the Mountain Plover (*Charadrius montanus*), 1969-1972. Technical Report 199. Grassland Biome, U.S. International Biological Program. 15 pp.
- Greenwood, R. J. 1986. Influence of striped skunk removal on upland duck nest success in North Dakota. Wildlife Society Bulletin. 14 (1): 6-110.
- Hall, E. R. 1981. The mammals of North America. John Wiley and Sons, New York, New York. Two Volumes. 1271 pp.
- Higgins, K. F. 1977. Duck nesting in intensively farmed areas of North Dakota. Journal of Wildlife Management 41: 232-242.
- Horn, E. E. 1938. Factors in nesting losses of the California Valley Quail. Transactions of the North American Wildlife Conference 3: 741-746.
- Jones, J. K., Jr., D. M. Armstrong, R. S. Hoffman, and C. Jones. 1983. Mammals of the northern great plains. University of Nebraska Press, Lincoln, Nebraska. 379 pp.
- Lein, M. R. 1968. The breeding biology of the Savannah Sparrow, *Passerculus sandwichensis* (Gmelin), at Saskatoon, Saskatchewan. M.Sc. thesis, University of Saskatchewan, Saskatoon, Saskatchewan. 171 pp.
- Murie, J. O. 1973. Population characteristics and phenology of a Franklin's Ground Squirrel (*Spermophilus franklinii*) colony in Alberta, Canada. American Midland Naturalist 90: 334-340.
- Sargeant, A. B., and P. M. Arnold. 1984. Predator management for ducks on waterfowl production areas in the northern plains. Proceedings of Vertebrate Pest Conference 11: 161-167.
- Sowls, L. K. 1948. The Franklin's Ground Squirrel *Citellus franklinii* (Sabine) and its relationship to nesting ducks. Journal of Mammalogy 29: 113-137.
- Sowls, L. K. 1955. Prairie ducks. Stackpole, Harrisburg, Pennsylvania. 193 pp.
- Stanton, F. W. 1944. Douglas Ground Squirrel as a predator on nests of upland game birds in Oregon. Journal of Wildlife Management 8: 153-161.

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Some Aspects of the Ecology of the Midland Painted Turtle, *Chrysemys picta marginata*, in Wye Marsh, Ontario

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Balcombe, Jonathan P., and Lawrence E. Licht. 1987. Some aspects of the ecology of the Midland Painted Turtle, *Chrysemys picta marginata*, in Wye Marsh, Ontario. Canadian Field-Naturalist 101(1): 98-100.

A total of 437 *Chrysemys picta marginata* were caught in the Wye Marsh area between May 1978 and October 1983. The sex ratio of males to females to juveniles was 1:1.39:0.54. Males reached sexual maturity at about 89 millimeters plastron length, females at about 126 millimeters. The relationship between age and length of turtles was non-linear. Growth showed a marked decrease following attainment of sexual maturity. Females were larger than males in all age classes above 5 years. Some notes on nesting are provided and the first Ontario record of second clutch laying in the Painted Turtle is reported.

Key Words: Midland Painted Turtle, *Chrysemys picta marginata*, ecology, growth, age, nesting, Wye Marsh, Ontario.

The Painted Turtle, *Chrysemys picta*, is the most northerly occurring and widespread turtle species in North America (Wilbur 1975; MacCulloch and Secoy 1983). Extensive literature on Painted Turtles has been published examining many aspects of its ecology (Sexton 1959a; Gibbons 1968; Wilbur 1975), but few of these studies are from the northern part of its range in Canada (Whillans and Crossman 1977; MacCulloch and Secoy 1983). Here we present data on age, growth and nesting from a population of Midland Painted Turtles (*C. p. marginata*) in south-central Ontario.

Methods

The 1000 hectare Wye Marsh is located just southeast of Midland, Ontario (44°53'N, 79°48'W). Stability of the marsh habitat and water level is maintained by a small dam which feeds a 1.5 kilometer stretch of the Wye River emptying into Georgian Bay.

From 1978 to 1983, turtles were captured using hand-held nets from boat and shore. Plastron length was measured to the nearest millimeter with a steel ruler and is the measurement used throughout this paper. Sex was determined by examining foreclaw length and cloacal position (Bayless 1975) and age by counting plastral growth annuli (Sexton 1959b). All turtles captured (with the exception of first-year individuals which have fragile scutes) were marked with notches filed into the marginal scutes (Cagle 1939) and released. With this technique, recaptures were identified and their growth determined. Nesting females were marked and measured only after they had covered their eggs. The number of eggs and the duration of laying were observed for seven females.

Results

During the five-year study we captured 437 Painted

Turtles. Most of these turtles were caught in open water associated with Common Cat-tail (*Typha latifolia*) mats. Of the total, 129 (30%) were males, 238 (54%) were females and 70 (16%) were juveniles. The ratio of males to females to juveniles was 1:1.39:0.54. This sample does not include 59 nesting females.

The largest male captured during this study measured 134 millimeters; the largest female measured 150 millimeters. Turtles less than 89 millimeters showed no secondary sexual characteristics and were classified as juveniles. Males matured at four years of age and females typically two years later.

Age of turtles ranged from hatchling to 10+ years. Growth annuli of older turtles were indistinguishable. Variation in the sizes of coeval (equal age) turtles was high and the relationship between age and length was not linear. Mann-Whitney U tests were used to compare the sizes of males and females of each age group, and females were significantly larger ($p < 0.05$) in the age classes 6, 7, 8, 9 and 10+ years. Size ranges of hatchlings, juveniles and adults of all age groups are presented in Table 1.

During the study, we recaptured 46 turtles, including 14 juveniles, 10 adult males and 22 adult females. Time intervals between initial and subsequent captures ranged from two weeks to four years.

The most rapid growth rates were those of juveniles but there was considerable variation in growth within this group. One third-year juvenile grew from 58 to 78 millimeters (body length increase of 34.3%) in 33 days from July to August of 1982. Another third-year turtle grew from 72 to 78 millimeters (8.3%) in 62 days from June to August 1982. Three juveniles grew 2-3 millimeters during a 30-day period in 1982. Other juveniles were recaptured too soon after initial marking to yield growth data.

The fastest growth recorded for adult turtles was

TABLE 1. Size ranges of the age classes of *Chrysemys picta marginata* in Wye Marsh.

Age in Years	Sex	Number Caught	Plastron length (mm)		
			Mean	SD	Range
Hatchling	Juvenile	10	31.0	5.4	25 - 40
1	Juvenile	13	48.0	3.1	43 - 54
2	Juvenile	15	59.9	4.5	50 - 68
3	Juvenile	17	75.0	9.3	58 - 88
4	Juvenile	3	81.7	4.9	76 - 85
	Male	5	93.0	2.5	89 - 96
	Female	5	91.4	3.9	89 - 98
5	Male	4	99.3	5.1	93 - 105
	Female	12	104.3	7.8	95 - 124
6	Male	7	105.3	3.2	101 - 111
	Female	10	117.6	7.7	107 - 132
7	Male	8	103.4	7.7	96 - 115
	Female	9	127.3	6.2	118 - 134
8	Male	3	109.0	5.3	103 - 113
	Female	13	129.5	6.7	118 - 137
9	Male	4	111.0	8.8	103 - 120
	Female	6	133.8	5.0	127 - 139
10	Male	0	—	—	—
	Female	4	136.0	5.6	131 - 144
10+	Male	37	117.8	8.7	104 - 134
	Female	36	140.8	4.8	130 - 150

that of a female, which grew from 111 to 118 millimeters (6.3%) in 76 days during the summer of 1983. Seven adults each grew 1-2 millimeters during a full summer and 25 adults showed no growth at all, including a male of 117 millimeters that was recaptured after four years (July 1979 to June 1983).

Between 7 June and 23 June 1982, and between 12 June and 3 July 1983, we caught 59 females at the nesting site, which is 1 hectare of mown grass adjoining the Wye River below the marsh. The smallest nesting female was 126 millimeters, another was 127 millimeters and 13 others measured were between 130 and 134 millimeters. The clutch sizes of seven females observed depositing eggs ranged from 7 to 9 eggs (mean = 7.25, SD = 1.0). The time to complete actual egg laying ranged from 4.6 to 6.0 minutes (mean = 5.2, SD = 0.7). Nesting activity occurred on dry days but increased during a heavy rain. All seven turtles observed constructing nests and depositing eggs were seen to urinate on the soil during digging. As well, nine other females observed in nesting behavior urinated while being handled.

During 1983 two females were recaptured, each subsequently laying a second clutch. The first female, measuring 130 millimeters, nested at 1830 h on 12 June (7 eggs) and re-nested at 1820 h on 22 June. The second, measuring 131 millimeters, nested at 1953 h on 15 June and re-nested at 1832 h on 26 June (7 eggs). Although we did not count eggs from both clutches of

the two females, each female excavated and recovered both of her nests.

While predation on nests was not studied, it was reported to us that at 1400 h on 2 July 1983, an adult Woodchuck (*Marmota monax*) was seen digging up a Painted Turtle nest and eating the eggs.

Discussion

Although the sex ratio at Wye Marsh appears skewed towards females, other studies have attributed sex ratio bias to sampling method (Ream and Ream 1966; Gibbons 1970), and we cannot exclude this possibility.

Previous studies have shown that size at maturity in the Painted Turtle increases with increasing latitude (Ernst 1971; Moll 1973). Plastron lengths at maturity of *C. p. dorsalis* (Southern Painted Turtle) in Louisiana and Arkansas were determined to be 60-65 millimeters for males and 100 millimeters for females (Moll 1973). In Michigan, *C. p. marginata* males are mature at about 80 millimeters and females at about 115 millimeters (Gibbons 1967). Our measurements of 89 millimeters for males and 126 millimeters for females are consistent with the generalization that size at maturity changes with increasing latitude. In the largest subspecies, *C. p. bellii* (Western Painted Turtle), a northern population (MacCulloch and Secoy 1983) has been found to mature at a larger body size than does the same subspecies further south

(Christiansen and Moll 1973).

Growth of Wye Marsh turtles was most rapid in juveniles and a non-linear age-length relationship was observed. Ernst (1971) and MacCulloch and Secoy (1983) also reported non-linear age-length relationships for *C. picta*, and a marked reduction in annual growth associated with the attainment of sexual maturity in this species has been established in several studies (Wilbur 1975; Bury 1979).

Adult sexual dimorphism with respect to size is more pronounced in the Wye Marsh population than was found in *C. p. bellii* from Saskatchewan (MacCulloch and Secoy 1983), where size differences were significant only between the 10+ (male) and combined 11, 12 and 12+ (female) age classes.

Our observations on nesting behaviour are essentially the same as those described by Whillans and Crossman (1977) for the Midland Painted Turtle. As well, the clutch size of 7-9 eggs (mean = 7.25) at Wye Marsh is similar to that of 6-9 (mean = 7.2) eggs reported by Whillans and Crossman (1977) and for other Midland Painted Turtle populations (Ernst and Barbour 1972). These northern clutch sizes are larger than those from southern Painted Turtle populations (Christiansen and Moll 1973; Moll 1973).

Second clutch laying for *C. picta* has been suggested as likely by Powell (1967), Christiansen and Moll (1973) and Moll (1973), but has only been reported from direct observation by Snow (1980) in northern Michigan. Our two additional observations may indicate that second clutches regularly occur in a few females in northern populations.

Although skunks, raccoons and foxes are common predators of turtle nests, Snow (1982) observed Eastern Chipmunks (*Tamias striatus*) preying on eggs. The Woodchuck has not been previously described as a predator of turtle eggs, and given its abundance and large body size, the Woodchuck may be important in this regard.

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Literature Cited

Bayless, L. E. 1975. Population parameters for *Chrysemys picta* in a New York pond. *American Midland Naturalist*

- 93: 168-175.
- Bury, R. B. 1979. Population ecology of freshwater turtles. Pp. 571-602 in *Turtles: Perspectives and Research*. Edited by M. Harless and H. Morlock. Wiley and Sons, New York.
- Cagle, F. R. 1939. A system of marking turtles for future identification. *Copeia* 1939: 170-173.
- Christiansen, J. L., and E. O. Moll. 1973. Latitudinal reproductive variation within a single subspecies of painted turtle, *Chrysemys picta bellii*. *Herpetologica* 29: 152-163.
- Ernst, C. H. 1971. Growth of the painted turtle, *Chrysemys picta* in southeastern Pennsylvania. *Herpetologica* 27: 135-141.
- Ernst, C. H., and R. W. Barbour. 1972. *Turtles of the United States*. The University Press of Kentucky. 347 pp.
- Gibbons, J. W. 1967. Variation in growth rates in three populations of the painted turtle, *Chrysemys picta*. *Herpetologica* 23: 296-303.
- Gibbons, J. W. 1968. Reproductive potential, activity, and cycles in the painted turtle, *Chrysemys picta*. *Ecology* 49: 399-409.
- Gibbons, J. W. 1970. Sex ratio in turtles. *Research in Population Ecology* 12: 252-254.
- MacCulloch, R. D., and D. M. Secoy. 1983. Demography, growth and food of Western Painted Turtles, *Chrysemys picta bellii* (Gray) from southern Saskatchewan. *Canadian Journal of Zoology* 61: 1499-1509.
- Moll, E. O. 1973. Latitudinal and interspecific variation in reproduction in the painted turtle, *Chrysemys picta*. *Herpetologica* 29: 307-318.
- Powell, C. 1967. Female sexual cycles of *Chrysemys picta* and *Clemmys insculpta* in Nova Scotia. *Canadian Field-Naturalist* 81: 134-140.
- Ream, C., and R. Ream. 1966. The influence of sampling methods on the estimation of population structure in Painted Turtles. *American Midland Naturalist* 75: 325-338.
- Sexton, O. J. 1959a. Spatial and temporal movements of a population of the painted turtle, *Chrysemys picta marginata* (Agassiz). *Ecological Monographs* 29: 113-140.
- Sexton, O. J. 1959b. A method of estimating the age of painted turtles for use in demographic studies. *Ecology* 40: 716-718.
- Snow, J. E. 1980. Second clutch laying by painted turtles. *Copeia* 1980: 534-536.
- Snow, J. E. 1982. Predation on painted turtle nests as a function of nest age. *Canadian Journal of Zoology* 60: 3290-3292.
- Whillans, T. H., and E. J. Crossman. 1977. Morphological parameters and spring activities in a central Ontario population of Midland Painted Turtles, *Chrysemys picta marginata* (Agassiz). *Canadian Field-Naturalist* 91: 47-57.
- Wilbur, H. M. 1975. The evolutionary and mathematical demography of the turtle *Chrysemys picta*. *Ecology* 56: 64-77.

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Parental Roles and Nestling Foods in the Rough-legged Hawk, *Buteo lagopus*

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Smith, Cindy J. 1987. Parental roles and nestling foods in the Rough-legged Hawk, *Buteo lagopus*. Canadian Field-Naturalist 101(1): 101-103.

A Rough-legged Hawk (*Buteo lagopus*) nest was observed for 52 hours between 31 July and 10 August 1984 at Sarcpa Lake, Northwest Territories. There was no difference between male and female hawks in type or rate of delivery of prey (primarily lemmings) brought to the nest. The female contributed more food to the young and spent less time in protection of young than would have been predicted for a raptor showing moderate reversed size dimorphism, possibly because of the short breeding seasons in the Arctic.

Key Words: *Buteo lagopus*, Rough-legged Hawk, sexual dimorphism, provisioning, Northwest Territories.

Reversed size dimorphism in raptors is usually associated with differences between the sexes in parental roles during the breeding season. For example, females are reported to spend more time than males in protection of nestlings and less time in hunting for food for the young when the young are small (Newton 1979). Furthermore, females are reported to deliver larger prey items than the males to nestlings (Newton 1979). In this note, I compare parental roles of the sexes in a raptor showing moderate reversed size dimorphism, the Rough-legged Hawk (*Buteo lagopus*) (Newton, 1979).

Methods

I observed a Rough-legged Hawk nest from 31 July to 10 August 1984 at Sarcpa Lake, Northwest Territories (68°32'N, 83°16'W). This area is high Arctic tundra consisting of elevated rocky areas and sloping sedgy meadows. The nest was on the north west face of a 20 m high cliff, 2 m from the top. On 31 July, the nest contained five young, which were approximately 12 days old, judging from the amount of gray and white down on each chick, with the two largest nestlings showing some wing feathers (Brown and Amadon 1968; Harrison 1978).

Observations were made from a blind approximately 60 m from the nest on the opposite side of the ravine, using a 40x spotting scope. Observation periods were generally 4-5 hours in length, between 0900 and 2000 h EDT. I recorded the time of each visit, the sex of the visiting parent, the identity of the prey item brought to the nest, and which nestling received the prey. Information was dictated into a portable tape recorder and later transcribed. My presence in the blind did not appear to affect the behaviour of the hawks.

Results

The male and female were readily distinguishable: the male was smaller, had a multibanded tail and was a dark phase bird, whereas the female had a single black subterminal band on the tail and was a light phase bird. On the first day of observations the male tore up the prey and fed it to the nestlings, but on subsequent days he dropped prey on the nest and flew off. The female tore up prey which she brought to the nest, as well as the prey dropped by the male, for the first three days. From the fourth day until the end of observations the nestlings swallowed prey items whole.

There was no significant difference between the male and female in the number of prey brought to the nest during the 10 days of observation (Table 1: $Z = 0.28$, $P > 0.05$, Wilcoxon signed-rank test). Daily feeding rates were 0.84 prey/h for the male and 0.94 prey/h for the female and showed no difference for single days of the study (Table 1), except on the last day when the male did not feed the young.

Ninety-three prey items were identified, of which the male contributed 44 and the female 49 (Table 2: no intersexual difference: $\chi^2 = 0.17$, $P > 0.05$). Brown Lemmings (*Lemmus sibiricus*) and Collared Lemmings (*Dicrostonyx torquatus*) were the main prey types (Table 2), comprising 91% of all prey brought to the nestlings. The proportion of lemmings did not differ between the sexes; for the male, 38 of 44 prey items (86%) and for the female 47 of 49 prey items (96%) were lemmings ($\chi^2 = 1.61$, $P > 0.05$). Only the male supplemented the diet of the nestlings with birds.

There was no difference between the four largest nestlings in number or type of prey eaten. Nestlings 1 to 4 (ranked largest to smallest) consumed 32, 30, 29 and 28 partial or whole lemmings, respectively. Nestling 5 was the smallest of the brood and ate only 8 partial lemmings during the observation periods.

TABLE 1. Comparison of daily feeding rates between the male and female Rough-legged Hawk at a nest.

Day	Observation time (h)	Male contribution		Female contribution	
		Number of prey	Rate (prey/h)	Number of prey	Rate (prey/h)
1	4.75	5	1.1	3	0.63
2	8	5	0.63	4	0.50
3	6	8	1.3	9	1.5
4	8.75	13	1.5	11	1.3
6	5	4	0.80	3	0.6
7	8	4	0.5	5	0.63
9	2.5	1	0.4	1	0.4
10	5	2	0.4	8	1.6
11	1.75	2	1.1	2	1.1
12	3.5	0	0.0	3	0.86
Total	52.25	44	0.84	49	0.94

TABLE 2. Prey items contributed by the male and female Rough-legged Hawks.

Prey Items	Male contribution		Female contribution		Total	
	Number	%	Number	%	Number	%
<i>Dicrostonyx torquatus</i> (Collared Lemming)	21	47.7	20	40.8	41	44.0
<i>Lemmus sibiricus</i> (Brown Lemming)	17	38.6	27	55.1	44	47.3
<i>Plectrophenax nivalis</i> (Snow Bunting)	3	6.8	0	0.0	3	3.2
<i>Calidris</i> spp. (sandpiper)	2	4.5	0	0.0	2	2.2
<i>Pluvialis dominica</i> (Golden Plover)	1	2.3	0	0.0	1	1.1
<i>Clethrionomys gapperi</i> (Red-backed Vole)	0	0.0	1	2.0	1	1.1
<i>Mustela erminea</i> (Short-tailed Weasel)	0	0.0	1	2.0	1	1.1
Total	44	99.9	49	99.9	93	100

Nestling 5 died on 6 August after being pecked repeatedly by its two largest siblings and was missing from the nest the following day.

Discussion

Raptors which exhibit moderate to large size dimorphism usually display measurable behavioural differences between the sexes (Newton 1979). However, no measurable differences in rates or type of prey delivered to nestlings were found between the male and female Rough-legged Hawks. Feeding rates for both sexes were slightly less than one per hour, and both parents fed the young primarily on lemmings.

The only indication of a difference was that the male occasionally brought birds as prey to the nestlings, possibly because the male's smaller size and greater manoeuvrability allowed it to capture more agile prey. Other studies (McEwen 1957; Sealy 1966; White and Cade 1971; Springer 1977; Kuyt 1980) on nesting Rough-legged Hawks have also reported birds as prey, but the parent that captured the prey was not determined.

Data in this study on feeding behaviour in nesting Rough-legged Hawks differ from some previous reports. Female Rough-legged Hawks have been reported as not hunting at all for food for the young

(Brown and Amadon 1968), or as remaining close to the nest and not hunting until the young are well-feathered (Harrison 1978). Not only did the female contribute substantially to the feeding of the nestlings but she left the nest and hunted for prey while the young were still covered in down. Furthermore, she contributed equal amounts of food, the same types of food, and at the same rate as the male. Observations on nest protection also do not support reports of nest-guarding behaviour primarily by the female; the male frequently hunted close to the nest, approached and called when humans were present, and chased away potential nest predators such as the Glaucous Gull (*Larus hyperboreus*).

The female Rough-legged Hawk appeared to spend less time in nest protection and more on provisioning the young than would be predicted from explanations of reversed size dimorphism in raptor species in temperate areas. A possible explanation is that time is important in the raising of young in the high Arctic. A shortened breeding season may require quick maturation of the young so that the best strategy for the female is to hunt for prey for the nestlings in order to ensure a steady supply of food.

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Gestation Periods in Two Yearling Captive Moose, *Alces alces*, in Saskatchewan

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Stewart, R. R., L. Comishen Stewart, and J. C. Haigh. 1987. Gestation periods in two yearling captive Moose, *Alces alces*, in Saskatchewan. Canadian Field-Naturalist 101(1): 103-104.

The gestation period of two captive yearling bred female Moose (*Alces alces*) was estimated at 216 days for a cow with twin calves and 218 days for a cow with a singleton.

Key Words: *Alces alces*, captive Moose, gestation, Saskatchewan.

The length of the gestation period for captive Moose (*Alces alces*) in Sweden (Skuncke 1949, cited by Markgren 1969) and the Soviet Union (Knorre 1959, cited by Markgren 1969) was estimated to range from 226-244 days with respective means of 236 and

Literature Cited

- Brown, L., and D. Amadon. 1968. Eagles, hawks and falcons of the world. McGraw-Hill, New York.
- Harrison, C. 1978. Nests, eggs and nestlings of North American birds. Collins, Toronto.
- Kuyt, E. 1980. Distribution and breeding biology of raptors in the Thelon River Area, Northwest Territories, 1957-1969. Canadian Field-Naturalist 94: 121-130.
- McEwen, E. H. 1957. Birds observed at Bathurst Inlet, Northwest Territories. Canadian Field-Naturalist 71: 109-115.
- Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, South Dakota.
- Sealy, S. G. 1966. Notes on the Rough-legged Hawk in the Perry River region, Northwest Territories. Blue Jay 24: 127-128.
- Springer, A. M. 1975. Observations on the summer diet of Rough-legged Hawks from Alaska. Condor 77: 338-339.
- White, C. M., and T. J. Cade. 1971. Cliff-nesting raptors and ravens along the Colville River in arctic Alaska. Living Bird 10: 107-150.

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234 days for each area. Peterson (1974) reported the gestation period to be 240-246 days for North American Moose. In mid-October 1983, a yearling bull was introduced into an enclosure in Saskatchewan which held two yearling cows. Precopulatory

mounting was observed with one cow on November 5 and the other on November 17; vaginal discharge believed to be seminal fluid was observed from the cows on each day, respectively, and thus we assumed mating to have occurred at that time. Mating behaviour ceased within 24 hours of the estimated dates of conception. The cow mated first produced twin calves 7 June 1984 and the other had a singleton 21 June. Blood samples were harvested from the moose at weekly intervals throughout pregnancy. Radioimmunoassays for serum progesterone confirmed the estimated dates of copulation (Stewart and Comishen Stewart 1985). The estimated gestation period was 216 days for the cow producing twin calves and 218 days for the cow with a singleton. These represent the shortest gestation periods reported for captive moose.

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Literature Cited

- Markgren, G.** 1969. Reproduction of moose in Sweden. *Viltrevy* 6(3): 127-299.
- Peterson, R. L.** 1974. A review of the general life history of moose. *Le Naturaliste canadien* 101: 9-21.
- Stewart, R. R., L. Comishen Stewart, and J. C. Haigh.** 1985. Levels of some reproductive hormones in relation to pregnancy in moose: a preliminary report. *Alces* 21: *In press*.

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First British Columbia Record of the Black-throated Blue Warbler, *Dendroica caerulescens*

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Davidson, Gary, and Linda Van Damme. 1987. First British Columbia record of the Black-throated Blue Warbler, *Dendroica caerulescens*. *Canadian Field-Naturalist* 101(1): 104-105.

A Black-throated Blue Warbler (*Dendroica caerulescens*) photographed at Creston, British Columbia, on 22 September 1984 is the first recorded occurrence of this species in British Columbia.

Key Words: Black-throated Blue Warbler, *Dendroica caerulescens*, British Columbia, first record.

The Black-throated Blue Warbler (*Dendroica caerulescens*) summers from southeastern Manitoba east through southern Ontario, southern Québec and the Maritime Provinces and south to the northeastern United States. It winters primarily in the West Indies (A. O. U. 1983; Godfrey 1966). Although this colourful warbler migrates chiefly through eastern North America, it is casual in Alberta, Saskatchewan and Oregon. There are at least eleven documented occurrences in Alberta, the most recent being in fall 1979 (Salt 1973; Salt & Salt 1976; B. McGillvray, personal communication).

On 22 September 1984 by the boardwalk directly

behind the Creston Valley Wildlife Centre, 425 km east of Vancouver, British Columbia, we saw a small bird fly up from the low shrubbery into a group of small deciduous trees. The bird was an adult male Black-throated Blue Warbler. We observed it for about twenty minutes, and several 35 mm colour slides were taken, some from as close as three metres. These were added to the provincial photo-record collection (see Campbell and Stirling 1971), which is now housed at the British Columbia Provincial Museum, in Victoria [British Columbia Provincial Museum Photo No. 937]. The warbler appeared tired and wanted to sleep, despite repeated attempts by a

Song Sparrow (*Melospiza melodia*) and a Lincoln's Sparrow (*Melospiza lincolni*) to drive it away. It was still in the same tree when we left, but it was not seen again later. This constitutes the first known occurrence of the Black-throated Blue Warbler in British Columbia (see Campbell 1984).

Literature Cited

American Ornithologists' Union. 1983. Check-list of North American birds, sixth edition. Allen Press, Inc., Lawrence, Kansas. 877 pp.

Campbell, R. W. 1984. Checklist of British Columbia birds (to May 1984). British Columbia Provincial Museum, Victoria.

Campbell, R. W., and D. Stirling. 1971. A photoduplicate file for B. C. vertebrate records. Syesis 4: 217-222.

Godfrey, W. E. 1966. The birds of Canada. National Museum of Canada Bulletin No. 206, Ottawa, Ontario. 428 pp.

Salt, W. R. 1973. Alberta vireos and warblers: families Vireonidae and Parulidae distribution and breeding. Provincial Museum and Archives of Alberta Publication No. 3, Edmonton, Alberta. 141 pp.

Salt, W. R., and J. R. Salt. 1976. The birds of Alberta. Hurtig Publishers, Edmonton, Alberta. 498 pp.

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Siblicidal Attacks by Great Blue Heron, *Ardea herodias*, Chicks in a Southern Ontario Heronry

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David, Sheila, and Michael Berrill. 1987. Siblicidal attacks by Great Blue Heron, *Ardea herodias*, chicks in a southern Ontario heronry. Canadian Field-Naturalist 101(1): 105-107.

Sibling aggression and siblicide occurred frequently among nestlings that were fed large prey in a colony of Great Blue Herons (*Ardea herodias*) in southern Ontario. Victims of aggression were invariably the smallest siblings. Aggression was observed in 15 of the 23 nests we observed, and apparent siblicide occurred in nine of these nests. The frequency of aggression and associated nestling mortality appeared to be related to brood size. Aggressive attacks were stimulated by the arrival of an adult, and continued to occur until the chicks were nearly ready to fledge.

Key Words: Great Blue Heron, *Ardea herodias*, siblicide, Ontario.

Asynchronous hatching occurs in a number of bird species (Clark and Wilson 1981; Meyburg 1974). Since this occurs mainly in those species that appear to depend upon a highly variable food supply for rearing young, it has been interpreted as an adaptation by the parents to facilitate brood reduction when food is scarce (e.g. Quinney 1982; O'Connor 1978). Asynchronous hatching and brood reduction are common in Great Blue Heron (*Ardea herodias*) populations (Pratt 1970; Quinney 1982), but recent studies on ardeids have suggested that the aggressive behaviour of siblings may be a direct cause of mortality even though food resources are sufficient for the entire brood to survive (Mock 1984; Werschkul 1979).

Mock (1985) proposed that stable, age-dependent dominance hierarchies may be established among ardeid siblings that would benefit senior siblings and parents, should food amount become limited. Great Blue Heron nestlings in Texas that were fed large prey indirectly formed dominance hierarchies, but most

siblings did not fight one another, and the incidents involving siblicide were low (< 5%). Mock (1985) attributed the low occurrence of siblicide to non-limited food and prey size. Nestlings in Nova Scotia were fed prey of increasingly large size, and the primary cause of nestling mortality appeared to be starvation of youngest nestlings because of their failure to compete successfully with older siblings for food (Quinney 1982).

We sought to determine whether sibling aggression and siblicide occurred, and if so, how they influenced Great Blue Heron breeding success in a southern Ontario colony.

Methods

Great Blue Herons were observed at the Scugog Island colony, Ontario County, in southern Ontario (44° 20' N; 78° 50' W). The colony is located in 1.3 ha of a deciduous forest at Pine Point on the eastern side of the island. The number of heron nests in the colony increased from six in 1959 (Tozer and Richards 1974)

to approximately 190 in 1969 and has remained at about that level since then. Most of the recent nests have been built near the tops of Sugar Maple (*Acer saccharum*), Beech (*Fagus grandifolia*) and White Ash (*Fraxinus americana*) trees, 15–25 m high in the northern section of the woodlot (Young 1983). Scugog Island has extensive marsh areas on the north-western and south-eastern shores, providing convenient foraging grounds for the herons.

Twenty-five nests located close together on the south-east part of the heronry were chosen for study because they could be observed easily from a ground-level blind situated 20 m from the closest nest. Observations began on 17 May 1984, after the completion of pair formation and egg laying. Herons were observed for a total of 165 hours (3–5 hours per day, 4–5 times per week) until 19 July when most had fledged. Nests were observed to determine the stimulus and frequency of attacks that occurred among siblings. An attack was defined as an encounter in which one chick stabbed its sibling with its bill, visibly wounding it or causing it to miss a feeding. Determination of the age of heron chicks was based on a combination of changes in their feeding behaviour and development of their motor skills (Pratt 1970).

Results and Discussion

Of the 25 pairs of Great Blue Herons observed, only one failed to produce young. Another pair, nesting in a dead beech tree, hatched nestlings but lost them when the nest was blown down in a storm on 25 May. A total of 70 chicks was observed in the remaining 23 nests, with a range of 2 to 4 chicks per nest (Table 1). Ten chicks died before fledging, a mortality rate of 14.3%, resulting in a fledging rate of 2.6 chicks per successful nest.

The prey regurgitated by an adult was small and unidentifiable until the chicks reached two weeks of age. After this stage, there was only one regurgitation per feeding, and the regurgitated prey was invariably one large fish 10–20 cm long. In those instances, one chick often would grasp the fish before it was

completely out of the adult's bill, but monopolization of the fish by a single chick was seldom observed. A tug of war occasionally resulted between two chicks over one fish, and their struggle sometimes continued for several minutes after the adult had left.

A total of 85 sibling attacks was observed in 15 of the 23 nests. Of the 85 attacks, only five occurred while the chicks were alone at the nest; all other attacks apparently were elicited by the return of the adult and often began even before the adult landed on the nest. Attacks were first visible from our blind when the chicks became a week old, and continued to occur until the chicks were ready to fledge (Table 2). Chicks that were attacked were noticeably smaller than the rest of the brood, and presumably were the last to hatch. The aggressor struck its sibling in the neck or head area, most commonly on the back or the side of the head. The victim walked to the edge of the nest, staggering, while squawking loudly, and hung its head and neck over the edge. The attack either stopped at this point, with the victim remaining hanging over the nest edge, or the attacker continued stabbing at the victim's neck. The attacked chick did not participate in the subsequent feeding bout.

As the attacked chicks became more mobile (5–6 weeks old), they were able to walk out on branches adjacent to the nest to escape. One or more of the chicks remaining in the nest stared at the ousted sibling and made thrusts as if to stab the sibling if it made a motion to return to its nest. One such chick, attempting to return to its nest following the arrival of a parent with food, was repeatedly grabbed by the neck by a sibling, lost its footing on the branch and fell to the ground. This was assumed to be the cause of death of another chick last seen on an outer branch near its nest. Attacks were relatively more frequent in nests with an initial brood size of four (Table 1). At no time did a parent interfere in sibling attacks, but occasionally it left without regurgitating when attacks continued for several minutes.

Deaths associated with siblicidal attacks occurred in chicks ranging from two to six weeks old (Table 2). Of the ten chick deaths which occurred, two

TABLE 1. Summary of brood sizes, sibling attacks and deaths of chicks in a heronry in southern Ontario observed for a total of 165 hours over an eight-week period.

Brood size	No. of Broods	No. of Attacks Observed	Mean No. of Attacks	No. of Deaths	No. Fledged
			Observed/ Brood/Hr.		
2	4	1	0.001	2	6
3	14	44	0.018	3	39
4	5	36	0.047	5	15

TABLE 2. Number of attacks and deaths observed in relation to age of chicks in 23 nests in a southern Ontario heronry.

Chick Age (weeks)	Hours Observed	No. of Attacks Observed	No. of deaths
< 1	—	—	1
1 - 2	24	10	2
2 - 3	30	16	1
3 - 4	26	17	1
4 - 5	32	14	4
5 - 6	33	15	1
6 - 7	20	9	0

resulted from chicks falling to the ground after escaping from the nest. Although their deaths were not witnessed, seven other chicks which had been previously attacked died. The remaining death was of a one-week old chick in a brood that presumably only had two chicks. As we could not count the chicks until they were one week old, it is possible that other first-week deaths occurred, and we thus underestimated initial brood sizes. In all but one case death was caused by or related to attacks by larger, presumably older, siblings. Since the smallest nestling was invariably the one to die, a dominance, size-related hierarchy existed in the nests.

Mock (1984), observing chicks for 25 days post-hatch, recorded only one death due to wounding inflicted by siblings in thirteen broods of Great Blue Heron chicks compared with eight deaths in eleven broods of Great Egrets, *Casmerodius albus*. Several authors have stressed that the greatest cause of ardeid chick mortality was starvation of the younger, smaller chicks due to their inability to compete for food with older siblings (Pratt 1972; Collazo 1981; Quinney 1983). Death of older heron chicks by wounding from siblings has rarely been recorded (Milstein et al. 1970; McAloney 1973), perhaps because of the lengthy observations needed, since siblicidal events are usually very brief.

Mock (1984) also proposed that when prey are small enough to be monopolized, the occurrence of sibling rivalry should increase when food is limited; since Great Blue Herons usually take a large variety of prey types and sizes, siblicidal brood reduction should occur only when larger prey are unavailable. However, our observations indicate the siblicide may be relatively frequent, and that the arrival of parents with food can be the stimulus for attacks leading to siblicide, even when the prey items regurgitated by the parent are large and not easily monopolized by the chicks. It is possible, however, that the prey available to the parents was limited, thus inducing the sibling

attacks. If so, nestlings in nests in which sibling attacks and siblicide were not observed should have received more or larger prey items than the nestlings in the remaining nests; our present data are not extensive enough to test this. Within-species variation should not be surprising, however, in a species of such broad latitudinal distribution.

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Literature Cited

- Clark, A. B., and D. S. Wilson. 1981. Avian breeding adaptations: hatching asynchrony, brood reduction, and nest failure. *The Quarterly Review of Biology* 56(2): 253-277.
- Collazo, J. A. 1981. Some aspects of the breeding ecology of the Great Blue Heron at Heyburn State Park. *Northwest Science* 55(4): 293-297.
- McAloney, K. 1973. The breeding biology of the Great Blue Heron on Tobacco Island, Nova Scotia. *The Canadian Field-Naturalist* 87: 137-140.
- Meyburg, B. U. 1974. Sibling aggression and mortality among nestling eagles. *Ibis* 116(2): 224-228.
- Milstein, P. le S., I. Prestt, and A. A. Bell. 1970. The breeding cycle of the Grey Heron. *Ardea* 58: 171-255.
- Mock, D. W. 1984. Siblicidal aggression and resource monopolization in birds. *Science* 225: 731-733.
- Mock, D. W. 1985. Siblicidal brood reduction: the prey-size hypothesis. *American Naturalist* 125: 327-343.
- O'Connor, R. J. 1978. Brood reduction in birds: selection for fratricide, infanticide and suicide? *Animal Behaviour* 26(1): 79-96.
- Pratt, H. M. 1970. Breeding biology of Great Blue Herons and Common Egrets in central California. *The Condor* 72: 407-416.
- Pratt, H. M. 1972. Nesting success of Common Egrets and Great Blue Herons in the San Francisco Bay Region. *The Condor* 74: 447-453.
- Quinney, T. E. 1982. Growth, diet, and mortality of nestling Great Blue Herons. *The Wilson Bulletin* 94(4): 571-577.
- Quinney, T. E. 1983. Comparison of Great Blue Heron, *Ardea herodias*, reproduction at Boot Island and other Nova Scotia colonies. *Canadian Field-Naturalist* 97: 275-278.
- Tozer, R. G., and J. M. Richards. 1974. Birds of the Oshawa-Lake Scugog Region, Ontario. The Algar Press Ltd., Oshawa.
- Werschul, D. F. 1979. Nestling mortality and the adaptive significance of early locomotion in the Little Blue Heron. *The Auk* 96: 116-130.
- Young, C. A. 1983. The effects of a Great Blue Heron (*Ardea herodias*) colony upon vegetation at Pine Point, Scugog Island. M.Sc. thesis, Trent University, Peterborough, Ontario. 89 pp.

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Regurgitated Pellets and Late Winter Diet of Black-billed Magpies, *Pica pica*, in Central Alberta

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Reebs, S. G., and D. A. Boag. 1987. Regurgitated pellets and late winter diet of Black-billed Magpies, *Pica pica*, in central Alberta. *Canadian Field-Naturalist* 101(1): 108–110.

Analysis of pellets regurgitated by Black-billed Magpies (*Pica pica*) and collected beneath a communal roost near Edmonton, Alberta, revealed that these birds fed mostly on grain, berries, and garbage in late winter. Two-thirds of the pellets also contained bones of Meadow Voles (*Microtus pennsylvanicus*), suggesting predation on these small rodents to an extent greater than previously thought. Pellets were found in urban roosts as well as in an outdoor aviary housing captive magpies, indicating that pellet regurgitation is general in this species.

Key Words: Black-billed Magpie, *Pica pica*, regurgitated pellets, winter diet, Meadow Vole, *Microtus Pennsylvanicus*, Alberta.

On 20 and 26 February 1985, we found regurgitated pellets at a Black-billed Magpie, *Pica pica*, roost located in a rural area (53°28'N, 113°33'W) about 7 km south of Edmonton, Alberta. The roost, occupied by about 175 magpies at that time, was in a dense, natural stand of White Spruce, *Picea glauca*, on the slopes of a small creek. The frozen pellets were found either on the snow below trees that bore many droppings, or in a few cases, in the forks of branches within these trees. We believe they had been cast by magpies because no other bird that might have produced such pellets were ever recorded in the roost which had been under observation for more than five months as part of a study of the roosting behaviour of magpies (Reebs 1985).

We collected 121 pellets from below 36 trees. Sixty-four of the pellets appeared intact. These 64 pellets were dried, weighed, measured, and dissected. Average dry weight was 0.56 g (range: 0.27–0.96). Most pellets were oblong, measuring on average 25.4 mm long (range: 17.7–35.9) by 14.3 mm at largest diameter (range: 10.4–17.0) and 11.4 mm at smallest diameter (range: 8.2–13.8). For the most part, the pellets were composed of vegetable matter (Table 1). The fragmentary nature of this material made it impossible to determine quantitatively its precise origin, but it was apparent that grain hulls and chaff were abundant, along with some pieces of straw and bark. We think that oats (*Avena* spp.) and Common Wheat (*Triticum aestivum*) were the main grains consumed, based on the identification of some grains that were found whole in a few pellets. Such grains, commercially grown in Alberta, may have been obtained from spillage sites near silos and grain elevators. Pits and seeds were also present in many pellets. Prominent among them were pits of wild

cherries, *Prunus pensylvanica*, and *P. virginiana*, along with seeds from the berries of *Cotoneaster acutifolia* and *Shepherdia argentea*. Overall, the vegetable matter represented 92.3% of the total volume of material collected from the 64 pellets. The remainder consisted of matter of animal and inorganic origin (Table 1).

Notable by their high frequency of occurrence were small bones and teeth, apparently from microtine rodents. Such bones were found in 43 of the 64 pellets (usually 2–6 bones per pellet). Still intact among these bones were one skull and 12 jawbones still bearing teeth. Examination of their dental pattern revealed that they were all from Meadow Voles (*Microtus pennsylvanicus*). It is therefore reasonable to assume that most of the other bones also belonged to that species. Also present in a few pellets were fragments of eggshell, probably obtained from garbage, and egg rings of Forest Tent Caterpillar, *Malacosoma disstria*, which the magpies probably removed from the distal twigs of deciduous trees where the eggs had been laid the previous summer. Finally, a number of pellets contained small stones or pieces of concrete 2–5 mm in diameter, probably consumed by the birds as grit, and a few pieces of tinfoil, rubber, plastic wrapper, twine, and silicone sealant, probably obtained from garbage.

We subsequently found more pellets at two other magpie roosts located within the city of Edmonton. Mild weather at the time of collection caused the pellets to be wet and crumbly, thus preventing reliable measurement of their dimensions. They appeared, however, to be of the same size as the ones previously collected. Their composition also appeared to be similar, except that the presence of grain hulls and chaff could not be distinguished as easily as in the

TABLE 1. Contents of 64 regurgitated pellets of Black-billed Magpies collected under a communal roost in late February 1985, near Edmonton, Alberta.

Food item	Frequency of occurrence (%)	Total volume (%)
Vegetable matter		
Grain hulls and chaff	100.0	92.3
Pits and seeds	39.0	1.0
Animal matter		
Bones and teeth of		
<i>Microtus pennsylvanicus</i>	67.0	1.6
Egg shell	3.0	trace
Egg mass of		
<i>Malacosoma disstria</i>	3.0	trace
Inorganic matter		
Grit	27.0	4.0
Human refuse	18.0	1.0

other pellets. Of 12 pellets that were preserved as units, eight (67%) contained small mammalian bones, a level similar to that in the sample collected outside the city.

We also found pellets at the outdoor aviary of the University of Alberta, where 21 magpies were kept in captivity. The pellets were beneath the perches where the birds usually spent the night. These captive magpies had access only to dry dog food (bit-size pieces, Wayne Pet Food) and grit. The pellets from these birds were smaller than those found in the wild, averaging 17.1 (12.8–23.9) mm long by 11.4 (9.3–14.3) mm at greatest diameter and 9.3 (7.0–11.7) mm at smallest diameter. They were composed of a mixture of small stones and friable material similar to that of the dog food.

Pellet regurgitation has been reported for many corvids, especially crows, jays, and ravens (Terres 1980: 683). The habit has also been noted and used by Tatner (1983) during a study of the diet of an urban population of magpies in Britain. The fact that we found pellets under both rural and urban roosts, as well as in captivity where the only available food did not contain any sizeable non-digestible parts indicates that pellet-forming is a widespread, if not an obligatory (Terres 1980) activity in magpies. The rate at which magpies produce pellets in winter, however, is still unknown. We found no more than three pellets below any single tree, despite the fact that magpies often use the same perch night after night (Rees 1985). This may point either to a low rate of pellet production, or to their rapid disintegration and burial under successive snowfalls, or to their removal by rodents during the night. Tracks of small rodents and

Snowshoe Hares, *Lepus americanus*, were abundant throughout the roosting site.

Throughout their range, Black-billed Magpies are persecuted on account of their alleged propensity to attack small birds and their eggs in summer and farm animals in winter (Linsdale 1937). Yet very few studies have examined their food habits in North America (Kalmbach (1927) was the only major exception we found). The composition of the pellets we collected suggests that, in central Alberta, the Black-billed Magpie relies heavily on grain, berries, and garbage for survival in late winter. Studies of the Magpie's feeding habits in Britain have also identified grain as the staple of winter diet (Holyoak 1968; Tatner 1983). The British studies also showed that many insects and a few small mammals were consumed in addition to grain and seeds. In contrast, magpies wintering in Canada probably have limited access to insect material with which to supplement their diet. Egg rings of such plaque lepidopterans as the tent caterpillars, and overwintering adults of other insects (e.g. dipterans) and arachnids which find shelter in crevices in the bark of trees are possible exceptions. Both items, however, were either rare or absent in our sample, possibly because it was late in the winter and all readily available arthropods had already been gleaned, or because such adult arthropods are relatively soft-bodied and would be unlikely to leave evidence in a pellet.

Excluding road kills and garbage, small rodents may be, in most years, the only other natural source of animal food. The frequent occurrence of Meadow Vole bones in the pellets we found suggests that these small, winter-active rodents may indeed represent an important part of the magpie's winter diet, especially at the end of the season when mild weather may entice the voles to venture more often on the snow. In a study pertaining to the year-round diet of magpies in North America, Kalmbach (1927) noted high numbers of small mammal remains in February samples of stomach contents. He dismissed the importance of this observation on the grounds of small sample size. Yet, in the light of what was found in this study, and because magpies have, on several occasions, been observed killing and eating small rodents in winter (Boxall 1982; Reese 1985), the extent to which they use Meadow Voles as a food item by either scavenging or actively preying on them may be more important than previously thought, especially in northern populations.

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Literature Cited

- Boxall, P. C.** 1982. Further observations of predation by Black-billed Magpies on small mammals. *Journal of Field Ornithology* 53: 172-173.
- Holyoak, D.** 1968. A comparative study of the food of some British Corvidae. *Bird Study* 15: 147-153.
- Kalmbach, E. R.** 1927. The magpie in relation to agriculture. United States Department of Agriculture, Technical Bulletin 24: 1-29.
- Linsdale, J. M.** 1937. The natural history of magpies. Pacific Coast Avifauna, No. 25. Cooper Ornithological Club, Berkeley, California.
- Reebs, S. G.** 1985. Ecological aspects of sleep in black-billed magpies. M.Sc. thesis, University of Alberta, Edmonton. 86 pp.
- Reese, K. P.** 1985. Three additional cases of predation by magpies on small mammals. *The Great Basin Naturalist* 45: 152-153.
- Tatner, P.** 1983. The diet of urban Magpies *Pica pica*. *Ibis* 125: 90-107.
- Terres, J. K.** 1980. The Audubon Society encyclopedia of North American birds. Alfred A. Knopf, New York.

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Common Eider, *Somateria mollissima v-nigra*, in Southern Manitoba

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Two female Common Eiders were observed in southern Manitoba in early November 1984. One that died was preserved and identified as *Somateria mollissima v-nigra*. Two specimens collected in 1911 apparently belong to this subspecies. These appear to be the first records of the subspecies for the interior of southern Canada.

Key Words: Common Eider, *Somateria mollissima v-nigra*, Manitoba, first records.

On 2 November 1984 Martin G. Siepmann discovered a female Common Eider, *Somateria mollissima*, on the Red River at Lockport (50°05'N, 96°57'W), about 20 km north of Winnipeg, Manitoba. Other observers could not relocate the bird that day, but on 4 November a female — presumed to be the same individual — was seen on the river about 1 km north of Winnipeg (49°58'N, 97°03'W) by the author. It remained in the area until at least 6 November, when it was last seen by M. G. Siepmann.

A second female eider was observed near Lockport on 3 November by Gordon D. Grieveff. This bird was similar in plumage to the first eider, but it was somewhat darker on the head and it appeared to be weak, whereas the first bird flew well and had seemed healthy. On 5 November I found it dead on the ice along the riverbank, and took it to the Manitoba Museum of Man and Nature where it was prepared as a study skin (MMMN no. 1.2-4100) by Herbert W. R. Copland, Assistant Curator of Birds. He informed me that the bird had no fat and the stomach was empty. Copland sent the skin to Henri Ouellet, National

Museum of Natural Sciences, Ottawa, who identified it as *Somateria mollissima v-nigra*. To his knowledge this was the first record of this northwestern subspecies in the interior of southern Canada (H. Ouellet, personal communication to Copland). The occurrence of *S. m. v-nigra* in southern Manitoba was not altogether unexpected, since records exist for North Dakota, Minnesota, Kansas, and Iowa (American Ornithologists' Union 1957; Palmer 1976).

The only previous records of Common Eiders in interior Manitoba involved two specimens, both taken in 1911 (Lake Manitoba, 23 October, and Giroux, November; Godfrey 1966). The Lake Manitoba bird was shot by S. Spence and saved by the late Father Oscar Chagnon for his collection at the Sandy Bay Indian School. In the late 1960s rare specimens from this collection were donated to the Manitoba Museum; the eider is presently there (MMMN no. 1.2-2751). Copland informed me that this mounted bird is labelled "Pacific Eider" and the feather pattern around the bill indicates that it also belongs to the subspecies *S. m. v-nigra*. The Giroux

bird is not in the Manitoba Museum collection, but two photographs of its head and neck, taken in November 1920 by A. G. Lawrence, identify it as *S. m. v-nigra*. These photographs are in the files of the National Museum of Natural Sciences (W. Earl Godfrey, personal communication).

Historical weather maps for October 1911 do not reveal any weather pattern that could explain the occurrence of these birds (F. Luciow, personal communication, 1985).

In Canada, *S. m. v-nigra* breeds along the Beaufort Sea from the Alaska border east to Coronation Gulf (about 105° W) (Palmer 1976). It winters mainly in the Bering Sea and the Gulf of Alaska, and fall migration from the Canadian breeding grounds would take the bird west, away from Manitoba.

Palmer (1976) believes that a few birds migrate southward (up rivers) from the Beaufort Sea; this migration pattern might account for their inland occurrences. It is also possible that in 1984 the two eiders were carried inland by strong westerly winds (windforce 8) to the south of a depression centred over the Gulf of Alaska (approximately 56° N, 137° W) on 24 October. While this depression remained rather stationary on 24 and 25 October, a new low pressure area formed over northern Alberta on 25 October and

this system tracked almost due east during the next three days. Strong, cold northerly winds associated with this system reached southern Manitoba on 27 October, and this cold front, in addition to the aforementioned depressions, may have been responsible for the eiders' appearance here.

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Literature Cited

- American Ornithologists' Union.** 1957. Check-list of North American birds. Fifth Edition, third printing (including Supplements through 33rd). Port City Press, Inc., Baltimore, Maryland.
- Godfrey, W. E.** 1966. The birds of Canada. National Museums of Canada Bulletin No. 203. 428 pp.
- Palmer, R. S. Editor.** 1976. Handbook of North American birds. Volume 3. Yale University Press, New Haven, Connecticut.

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Sex Determination of the Black-billed Magpie, *Pica pica*

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In a northern population of Black-billed Magpies (*Pica pica hudsonia*) discriminant function analysis determined that the wing chord and the depth of the bill at the nostrils correctly classified 95% of juveniles according to sex. However for adults, the wing chord and the length of the upper mandible from the commissural point to the tip correctly classified 98% according to sex. These criteria of sex, unlike those used by previous investigators, can be used throughout the year.

Key Words: *Pica pica*, Black-billed Magpie, sex determination, Alberta.

When studying behavior of free-living birds, it is often essential to know their sex and age. Such information is often difficult to acquire when the plumage of the species is not sexually dimorphic. Although male Black-billed Magpies (*Pica pica*) generally are larger than females (Linsdale 1937; Baeyens 1979; Mugaas and King 1981; Reese and Kadlec 1982), overlap in their measurements makes it difficult to determine sex reliably. Some investigators relied on sexual behavior of individually-marked

birds to determine their sex (Baeyens 1981), but this is reliable only during the reproductive season and only for those birds which are reproductively active. The method of Reese and Kadlec (1982), based on sexually dimorphic external measurements, is reliable only from 1 January to 25 March and from 20 April to 1 June. They also used weight as a sex-determining character, but weight can be extremely variable (Table 1) and therefore could result in misclassification.

Discriminant function analysis (DFA) can help to

select those measurements which are most useful for classifying individuals according to sex (Green 1980; Reese and Kadlec 1982). This study was initiated to determine those measurements that could be used to classify birds according to sex throughout the year.

Methods

A sample of 70 adults (48 males and 22 females) and 63 juveniles (24 males and 39 females) was collected throughout the year of 1981-82 by the Division of By-Law Enforcement, City of Edmonton, Alberta. No less than seven birds were collected in a given month; however, more birds were caught during the spring and autumn. Eighteen measurements were taken on most birds using steel calipers, and weight was measured on a triple beam balance (Appendix 1). When repeating measurements the error was less than or equal to 1.5%. Missing values for a given variable were estimated by correlating the unknown with those two variables to which it was most related (Dixon 1979). The ages of all birds were determined by examining plumage based on methods by Linsdale (1937), Bent (1946), and Erpino (1968). Data were analyzed by a two-step discriminant function analysis (DFA) using Wilk's lambda for both sexes (Nie et al. 1979). Prior to the analysis, the entire data set was standardized.

Results

Means and standard deviations for the measurements appear in Table 1. To discriminate between the sexes of juveniles, DFA selected wing chord (WC) and depth of the bill at the mid-point of the nostril (DBN) as the most useful. These two measurements in combination allowed for correct classification of 60 (95%) of the 63 juvenile birds in the sample. Of the three birds that were misclassified, two were large females and the other a small male. The classification equation for males is $WC \times 6.099640 + DBN \times 3.019916 - 827.7061$, and for females is $WC \times 5.897157 + DBN \times 2.721537 - 748.2802$. The raw measurements of WC and DBN for a juvenile of unknown sex are put into both of the above equations. The bird is classified into the group with the highest score. Subsequently, the classification equations were used to determine the sex of 50 juvenile birds not used in this analysis. In this sample 47 (94%) out of the 50 were correctly classified according to sex. Of the three birds misclassified, two were small males and the other a large female.

For adults, DFA selected wing chord and length of bill (LB), measured from the commissural point to the tip of the upper bill, as the best discriminators of sex. Classification of birds using these two variables correctly classified 69 (98%) of the 70 in the sample.

The bird that was misclassified was a small male. The classification equations for males is $WC \times 12.30946 + LB \times 12.22224 - 1546.793$ and for females is $WC \times 11.45303 + LB \times 11.06318 - 1326.504$. The sex was determined for an additional 50 birds; all 50 (100%) were correctly classified.

Discussion

Wear on the tips of feathers has been documented for other birds (Vortkevich 1966). Consequently, feather wear was examined to determine whether it could influence the values of feather measurements obtained in this study. Measurements collected on 11 birds in the winter and again the following summer prior to molt indicated that there was significant feather wear on the central rectrices ($T = 4.6449$, $P < 0.01$, One-sided paired t-test). All other measurements including the bill measurements were not significantly different. Thus, wing chord and bill measurements have little variation attributable to wear.

Geographical variation in morphology may make the classification equations derived for this sample unreliable when determining the sex of distant populations. However, these data point out that wing and bill measurements can be used in the determination of sex and it is likely that similar sexual dimorphism occurs at other locations. Mean measurements taken from birds in other populations should be checked against the mean values presented in this paper.

Acknowledgments

I thank D. A. Boag, J. O. Murie, W. G. Evans and V. Lewin for their advice during portions of this research. I also thank W. Hochachka, B. Sevic, and P. Frazer for their technical assistance and V. Scharf for helping with all aspects of this study. Financial support was received from the Boreal Institute for Northern Studies, and from a Natural Sciences and Engineering Research Council Grant (A2010) to D. A. Boag. I would also like to thank the staff of the Department of Biological Sciences, State University of New York at Plattsburgh, New York, for their technical assistance.

Literature Cited

- Baeyens, G. 1979. Description of the social behaviour of the Magpie (*Pica pica*). *Ardea* 67: 28-41.
Baeyens, G. 1981. Functional aspects of serial monogamy: the Magpie pair-bond in relation to its territorial system. *Ardea* 69: 145-166.
Bent, A. C. 1946. Life histories of North American jays, crows and titmice. *Bulletin of the United States National*

TABLE 1. Measurements (mm) of age and sex classes of Black-billed Magpies collected in Edmonton, Alberta.

Character	Juvenile				Adult			
	male n = 24		female n = 39		male n = 48		female n = 22	
	\bar{X}	s.d.	\bar{X}	s.d.	\bar{X}	s.d.	\bar{X}	s.d.
Wing chord	204.0	6.5	195.7	4.7	207.1	4.3	192.4	3.2
Wing breadth	164.7	6.5	159.0	8.2	166.8	9.6	155.9	3.0
Length of black tip of fourth primary	24.5	3.1	22.8	2.5	19.6	4.0	20.6	5.1
Length of black tip of tenth primary	20.5	5.3	21.8	3.9	7.7	2.0	8.4	2.0
Length of white portion of the tenth primary	36.1	6.0	34.4	5.5	43.6	6.7	41.8	5.7
Length of lateral rectrix	137.1	8.5	133.2	8.5	140.3	8.2	129.1	5.4
Length of central rectrix	260.2	24.2	253.9	12.6	293.4	14.1	260.4	21.8
Length of upper bill from commissural point to tip	43.5	1.2	40.7	2.4	44.4	1.6	40.5	2.0
Length of bill from nostrils	26.5	1.1	25.4	3.9	26.3	1.6	23.6	1.6
Bill depth at commissural point	14.3	0.7	13.4	0.6	14.4	0.7	13.3	0.4
Bill depth at nostrils mid-point	13.6	0.6	12.6	0.5	13.4	0.7	12.5	0.4
Bill width at nostrils	12.2	0.8	11.5	0.8	12.3	0.8	11.2	0.7
Culmen length	31.2	2.9	29.9	3.1	31.2	2.2	27.9	2.8
Tarsus length	50.3	1.9	48.3	2.8	50.7	2.2	45.9	2.5
Foot length	77.1	2.5	74.2	2.8	77.4	3.3	72.0	3.4
Length of hallux	16.4	1.7	15.6	0.8	15.7	0.7	15.3	1.0
Length of third toe	24.3	1.9	23.2	1.6	23.8	2.2	22.6	1.9
Weight	197.5	25.6	170.9	16.1	192.6	17.2	181.4	28.2

Museum, No. 191.

Dixon, W. J. 1979. Biomedical Computer Programs P-Series, Description and Estimation of Missing Data (PAM). University of California Press, Berkeley, California.

Erpino, M. J. 1968. Age determination in the Black-billed Magpie. *Condor* 70: 91-92.

Green, P. T. 1980. Sexing rooks (*Corvus frugilegus*) by discriminant analysis. *Ibis* 124: 320-325.

Linsdale, J. M. 1937. The natural history of the magpies. Pacific Coast Avifauna No. 25. Cooper Ornithological Club, Berkeley, California.

Mugaas, J. N., and J. R. King. 1981. Annual variation of daily energy expenditure by the Black-billed Magpie: a

study of thermal and behavioral energetics. Studies in Avian Biology 5. Cooper Ornithological Society.

Reese, K. P., and J. A. Kadlec. 1982. Determining the sex of Black-billed Magpies by external measurements. *Journal of Field Ornithology* 53: 417-418.

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. Statistical package for the social sciences. Second edition. McGraw-Hill Book Company, New York.

Vortkevich, A. A. 1966. The feathers and plumage of birds. October House, Inc., New York.

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APPENDIX I. Description of measurements.

Wing chord	longest measurement from the bend of a closed wing to the longest primary	Bill depth at commissural	depth of the bill measured at the base of the upper mandible adjacent to the bristles
Wing breadth	longest measurement from the bend of a closed wing to the longest secondary	Bill depth at nostrils	depth of the bill measured at the mid-point of the nostril
Length of black tip of fourth primary	length of the black tip of the fourth primary measured from the distal tip of the white portion of the feather to the distal tip of the feather	Bill width at nostrils	width of the bill measured at the mid-point of the nostrils
Length of black tip of tenth primary	length of the black tip of the tenth primary measured from the distal tip of the white portion of the feather to the distal tip of the feather	Culmen length	length of the upper bill measured from the base of the upper mandible adjacent to the bristles to the distal tip of the upper mandible
Length of the white portion of tenth primary	length of the white portion of the tenth primary measured from the proximal (base) part of the feather to the distal tip of the feather	Tarsus length	length of the tarsometatarsus
Length of outside rectrix	length of either of the outside rectrices from the point of insertion of the calamus to the distal tip of the rectrix	Foot length	length of foot measured from the proximal end of the tarsometatarsus to the distal tip of the third toe
Length of central rectrix	length of the most central rectrices measured from the point of insertion of the calamus to the distal tip of the rectrix	Length of hallux	length of the hallux measured from the distal part of the pad to the proximal articulation of the toe
Length of upper bill	length of bill measured from the commissural point to the distal tip of the upper mandible	Length of third toe	length of the third toe measured from the distal tip of the foot pad to the proximal articulation of the toe
Length of bill from nostrils	length of the bill measured from the anterior edge of the nostril to the distal tip of the upper mandible	Weight	measured in grams on a triple beam balance (model 700, Ohaus Scale Corporation)

News and Comment

Annual Meeting: Raptor Research Foundation Inc.

The Raptor Research Foundation is an organization whose purpose is to stimulate the dissemination of information concerning raptorial birds among interested persons worldwide and to promote a better public understanding and appreciation of the value of birds of prey. Towards this objective, we are holding our annual meeting on 28-30 October 1987 at Boise, Idaho. The meeting will feature a symposium on the migration of raptors in western North America. General paper and poster sessions will follow the symposium.

Co-hosts for this meeting are the Bureau of Land

Management, Boise State University; Bureau of Reclamation, Idaho Power Company; Nongame Wildlife and Endangered Species Program, Idaho Department of Fish and Game; The Peregrine Fund, Inc., U.S. Fish and Wildlife Service.

RICH HOWARD

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Call for Assistance: Prairie-Northwest Territories Shorebird Survey Program

In 1987, the Canadian Wildlife Service, Western and Northern Region, will be initiating a program to survey major shorebird staging and nesting areas in the prairie provinces and the Northwest Territories. This project is part of the International Shorebird Surveys Program.

Similar surveys in Atlantic Canada have identified a number of significant staging areas in the Bay of Fundy. Many of these sites are now proposed for protection through the Ramsar Convention and the shorebird "Sister Reserves Program" (a hemisphere-wide system of reserves for shorebird protection). However, very little data exists on shorebird use in the prairie provinces or the Northwest Territories.

For this program to accomplish its objectives, the Canadian Wildlife Service will have to rely heavily on the efforts of outside individuals, organizations and

government agencies. Through your participation in this project, determination of potential Sister Reserves in these regions of Canada will be possible. So if you are interested in surveying shorebird staging and/or nesting habitats in the prairie provinces or the Northwest Territories, please contact me at the address or phone number listed below. Everyone who takes part in the program will receive the annual summary of the Canadian survey results (provincial breakdowns are included).

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Erratum for *The Canadian Field-Naturalist* 100(3)

Proulx, Gilbert, and Bruce M..L. Buckland. 1986. Productivity and mortality rates of southern Ontario pond- and stream-dwelling Muskrat, *Ondatra zibethicus*, populations. *Canadian Field-Naturalist* 100(3): 378-380.

In Table 1, Page 379, the number of breeding females from creek habitats should read 7 instead of 5.

Book Reviews

ZOOLOGY

Birds of Ontario

By J. M. Speirs. 1985. *Natural Heritage/Natural History*, Toronto. Volume I. 538 pp., illus. \$49.95; Volume II. 986 pp. \$24.95.

The first volume, devoted to providing a picture of the birds that have been known to occur in Ontario, consists of a series of colour photographs, usually two per page, each accompanied by a couple of paragraphs of text on the facing pages. If no photo was obtained, a blank space was left. However, over one third of the species have either no photo, are printed from very old and faded originals, are of very small images, or are so badly out of focus that they might just as well have not been used at all. Of the remainder, almost half are partly or completely out of focus or off colour. One is printed upside down, one or two sideways, and at least five are misidentified (Trumpeter Swan, Hairy Woodpecker, Swainson's Thrush, Swamp Sparrow, Smith's Longspur). I am sure that if more time and a wider selection of photographers had been used, a first rate series of photographs could have been found right here in Ontario.

The introductory sections are identical in both volumes (which are paginated separately). In addition, the text accompanying each picture is repeated as the first two paragraphs of the species accounts which make up the bulk of Volume II. The first of these paragraphs contains some general comments about the species, but unfortunately these are often some of the author's personal experiences and irrelevant to Ontario. Distribution and abundance information is included for some species only, and ranges are not sufficiently detailed to replace a field guide. There is no consistent format as to what is included in this paragraph. Identification features make up the second paragraph, but as this is "not intended primarily as a field guide," only some features are given. These would have been very useful with paintings, but the photographs are largely inadequate accompaniment.

Volume II begins with several key maps outlining Christmas bird count, breeding bird survey count and quadrat study areas used, and an end paper map gives provincial localities. Many localities mentioned in the text, however, do not appear on these maps and a few

locations are obviously misplaced (e.g. Glengarry County on the map of quadrat studies is placed in Quebec). Most of the explanatory notes for interpreting the accounts are not found until near the end! A literature cited section and indices end the book.

The bulk of each species account consists of lists of dates and localities, arranged by locality usually from south to north, where birds "have been" found during each of four seasons. Each seasonal section is a few lines to a full page long, consisting of a series of comments about the presence, numbers or breeding of the species in various parts of the province, largely from quoted works, but also observations without published sources. However, each account does not include a complete listing of regional works where appropriate; how the author chose what to include or ignore is not specified. Also, there is virtually no attempt to interpret this accumulated mass of material. The reader is left to try to figure out the significance of the material and the distribution of the species. Since many records relate to the situation in the late 1800s or the early part of this century, one does not know whether the information is of relevance today.

When available, data on recoveries of banded birds are included. Length, wingspread and weight measurements are given for each species, virtually all taken from other published sources. Units of measurement were not standardized, nor equivalents given. Some published papers dealing with individual species studied in Ontario (usually) are cited at the end of the appropriate accounts. Such references are not repeated in the literature cited section at the back where only those of a more general nature are given. However, the works cited in either place do not by any means constitute a complete list of regional works or of specific studies on Ontario birds. Again, how he made the choice of what to include is not specified. Space was not apparently limiting, for as many as 17 papers were cited for one species and there was usually plenty of space with each account. Some relatively obscure papers were cited, while more widely known literature was ignored.

Christmas bird count and breeding bird survey

findings between 1968 and 1977 are presented on maps, apparently for every species recorded, including vagrants, where there may be nothing but a single plus sign on a map. The average numbers counted per 100 party hours or per 50 count stops are set into blocks defined by latitude and longitude. Only the southern half of the province has such information, unfortunately, for this might have helped define ranges rather nicely for some songbirds at least. But for nonpasserines and less conspicuous passerines the breeding bird counts are probably largely a waste of paper if not actually misleading, for such species are not surveyed well by this technique. For example, I know there are at least 50 Osprey nests in a small area where the map shows none were recorded. These maps are rather small and figures could easily be misread.

Overall there is no clear indication given of the status of species included, and several even give the reader a choice (e.g. Yellow-billed Loon). There are several species included which do not appear on the Ontario Bird Records Committee list of provincial species, but no comments are made regarding their "hypothetical" status even where clear published rejections are found (e.g. Brewer's Sparrow). There are other species not included, e.g. Painted Bunting, where occurrence was published in the same issue of a journal from which another work was cited.

There is no clear indication given of the breeding status of any species. One has to read through a couple of paragraphs to find evidence, and then the information can be misleading. For example, the Yellow-crowned Night-Heron could be construed as a breeder, yet is not, and for the Common Eider, which does breed in Ontario, no evidence is provided.

For numerous species, the information given is not

up to date. For example, the nest record of Cinnamon Teal is not included, yet the information is given in a cited paper. There are many other examples where a work was cited in one place but ignored in another, despite the existence of records I would have thought were of greater interest than those that were cited.

There are incomplete sentences, references used that are not cited and numerous typographical errors, all suggesting rushing to meet a publication deadline, rather than trying to produce a high quality work. The fact that only one small section was ever read by an outside reviewer has undoubtedly contributed to many of the inconsistencies and omissions.

Given that everything written in Volume I is also available in the next volume, and that the quality of the pictures is so poor, I cannot see why anyone would willingly pay the price for it. There is a tremendous amount of information in Volume II, and I know the author has devoted years of his life to compiling it. If he had spent a few more months bringing things up to date, seeking a few more references, making sure references were treated consistently, providing some analytical comments and allowing reviewers to help him check this mass of items, the book would have been much more useful than it will be now without a thorough revision. This uninterpreted and incomplete compilation is unlikely to be of much interest to the average birder, and with the numerous omissions, cannot be accepted at face value by anyone. I cannot help but think that the author himself must be disappointed about what has happened in the end.

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Kirtland's Warbler: The Natural History of an Endangered Species

By Lawrence H. Walkinshaw. 1983. Cranbrook Institute of Science, Bloomfield Hills, Michigan. xii + 207pp., illus. U.S. \$11.95.

This book marks the 80th anniversary of the year (1903) when the breeding grounds of this bird were discovered in the Jack Pine forest region of Michigan's lower peninsula. The author, who began his field research in 1931, has compiled a considerable amount of data on this endangered species. His work builds on earlier studies by Norman Wood, Harold Mayfield, and Josselyn Van Tyne. Kirtland's Warbler, first described by Spencer F. Baird in 1852 from an Ohio specimen taken the preceding year, was evidently more numerous and occupied a more extensive breeding range from Missouri to Michigan

in the closing decades of the 19th century. There are modern sighting records from most neighboring states and provinces. Walkinshaw posits that cowbird parasitism, long recognized as a problem in modern warbler management, may also have been an important factor in this species' decline over the past century. This warbler winters only in the Bahamas. Kirtland's Warbler prefers habitats which have been naturally burned over in the past and where Jack Pines are under three meters in height. Peak utilization of nesting areas tends to take place between 11 and 17 years following a fire.

During the 1960s, the warbler population declined from slightly over 500 individuals to well under 300. From 1973 on, federal and state authorities

cooperated in removing cowbirds from warbler nesting areas, and in the ten years ending in 1983, some 40 000 cowbirds had been taken. As a result, the number of parasitized warbler nests declined from 69% to 6% in that decade. The U.S. Forst Service and the Michigan Department of Natural Resources have also planted Jack Pine and Red Pine forests at various locations in northern Michigan in an effort to present the species with a greater range of nesting options. The total population has remained low, however. A concluding chapter by Mark Bergland having to do with the factors influencing nesting indicates that despite improvements in the situation since cowbird control began in 1973, other forms of predation presently constitute the major component of mortality in this species.

The other predators responsible for destroying

warbler nests and nestlings include Blue Jays, Thirteen lined Ground Squirrels, Red Squirrels, and garter snakes. Inasmuch as the warbler is a ground nester, utilizing blueberry bushes and grass cover, and cannot protect its young against these other predacious species, no immediate practicable resolution to the population problem seems to be in prospect.

There is a considerable amount of statistical data to buttress the author's conclusions. This is an outstanding account of the status of an endangered species, and it deserves close study.

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Nest Boxes for Alberta Birds

By B. R. Shantz and M.D. Pearman. 1984. Ellis Bird Farm, Red Deer, Alberta. 41pp., illus. Free.

This handbook is a guide to providing nest boxes for 31 species of birds that occur in Alberta. Of these species, 23 have nation-wide distribution and 15 occur in two to four other provinces — making the book of potential interest to naturalists outside Alberta. The authors discuss identification, distribution, status, behaviour, nest description, habitat, nest boxes, and their placement for each species. They also provide many useful insights to monitoring nest boxes and artificially maintaining these bird populations. There are many attractive (some not too attractive) photographs and/or drawings of young and adult birds, eggs, and nest boxes. Key information on nesting and nest box construction for each species is isolated in a narrow column in the middle of the page.

The quality of the book is jeopardized by problems with format, editing, and proof-reading. The Table of Contents is inconsistent with the sections in the text: the order of headings in the Table of Contents differs from the text and titles of sections in the text are not found in the Table of Contents. Typographic errors are frequent (at least 28) and grammar is weak in some sections. Not all photographs are labelled and photographs of the Pileated Woodpecker and Screech Owl are provided without supporting text or reference. Visually, the book has a disarrayed, amateurish appearance because of the inconsistent layout of text and photographs. More seriously, information and illustrations that are only marginally useful are provided at the expense of material more directly related to the topic. For example, written descriptions and photographs of birds are provided at

the expense of more detailed descriptions or photographs of successful natural or artificial nest sites.

Most of the book is technical and descriptive. The exception, however, is that the authors advocate and attempt to justify the control of exotic, or non-native, species. The rationale for this normative position is based on the following statements: 1) the outcome of competitive interactions between exotic and some native species is negative and undesirable; 2) control of exotic species is necessary to enhance the survival of many native species; 3) some exotic species are a nuisance because they foul city yards and buildings with excrement; and 4) exotic species do not belong in naturally evolved ecosystems. The first three statements are true but cannot be applied unequivocally to exotic species only — these statements are also true for situations involving native species because they do not provide adequate distinction between the two groups and are not sufficient to evaluate the groups differently. For example, Violet-green Swallows successfully compete against bluebirds for nest sites and many native species, especially gulls, create a nuisance in cities. If we accept that the control of exotic species is justified under these circumstances, then we must also accept the control of native species under the same circumstances.

Statement 4 is critical to the authors' position because, if true, it would provide the necessary distinction to evaluate the two groups differently. The idea that exotic species do not belong in naturally evolved ecosystems arises from the fact that these species were dispersed, beyond their own means by man, to an ecosystem in which they did not evolve and

thereafter caused shifts in the ecological equilibrium of the ecosystems in which they were introduced. These ecological changes may be undesirable but is it correct to conclude that exotic species do not *belong* in naturally evolved ecosystems? On the surface, the statement may seem true if the analysis is based on the definitions of exotic (e.g. dispersed by man) and natural (e.g. nature as distinct from man). However, these concepts are abstractions of nature, not realities, and are used to classify nature for convenience and understanding. If we accept that humans are part of nature, as evolutionary theory dictates, we must accept a concept of ecology that includes the influences of humans. Furthermore, there is no difference ecologically between the dispersal of a

species by humans and any other biotic agent. Ecologically, these distinctions do not exist. To use these artificial distinctions in arguments that prescribe human responsibilities is to introduce logical inconsistencies. Certainly, 'exotic' species have caused drastic changes to ecosystems — so have other abiotic and biotic entities. The problem is to justify a framework to evaluate these changes and do so consistently.

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Marine Mollusks of Cape Cod

By Dr. Donald J. Zinn. 1984. Natural History Series No. 2. The Cape Cod Museum of Natural History, Brewster, Massachusetts. 78 pp., illus.

Beginner or advanced shell collectors, holiday beachcombers, or the gourmet looking for the unusual will all find something of interest in this little book.

The author has succeeded in his intention of providing a publication "to serve as an informal, introductory guide to the identification of molluscs found in the waters of Cape Cod." In the process he has also managed to cram between the covers various other useful pieces of molluscan information.

The reader is provided with species descriptions and line drawings by Terry Ellis for approximately 70 of the more common molluscs likely to be picked up on Cape Cod beaches. To specifically aid the novice the author has included, before the descriptions, a glossary of molluscan terminology as well as an outline of molluscan classification. It should be noted, however, that some of the scientific and common names employed in this publication are not those most currently used.

Useful information is provided concerning typical molluscan habitats and also some wise safety

precautions to follow while collecting. In the interest of conservation Dr. Zinn includes nine important rules for shellers to follow not only in Cape Cod but *wherever* their collecting may lead them. Information on methods of preparing the material collected is presented and suggestions are given for those interested in organizing a permanent shell collection.

One of the most intriguing sections is the one devoted to unusual recipes. While there are many recipes available for the ordinary oyster, scallop, and mussel, this collection of recipes provides ideas for the more adventurous cook. Molluscs not usually used as ingredients are featured and recipes for Roasted Limpets, Fried Razor Clams, and Moon-shell Supreme are just a few of the ones given to tempt your palate.

The curious beachcomber, sheller or gourmet planning a vacation in the Cape Cod area should be sure to save room in the suitcase or backpack for this useful and informative little guide.

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BOTANY

The Sunflower Family (Asteraceae) of British Columbia, Volume I — Senecioneae

By George W. Douglas, illustrated by Elizabeth J. Stephen. 1982. Occasional Papers Series No. 23. British Columbia Provincial Museum, Victoria. 180 pp., illus.

This well-planned and attractive book covers 68 taxa (56 species) of Senecioneae in 180 pages. For all

but one of the taxa there are distribution maps, and with three exceptions, all taxa are illustrated in full page, detailed, black and white line drawings. Both keys and descriptions are provided, with the descriptions and drawings generally on facing pages.

Appendices provide a list of the species included, a list of species excluded and synonyms for both groups. The list of synonyms seems very thorough. The bibliography extends to seven pages, and an index and a glossary are provided. The genera included are *Adenocaulon*, *Arnica*, *Cacaliopsis*, *Crocidium*, *Luina*, *Petasites*, *Tetradymia*, *Tussilago*, and, of course, *Senecio*.

As the first volume of a series, the book starts with an introduction to the family, with brief descriptions of historic and economic uses, floral anatomy, biology and pollination, and seed dispersal. A key to the tribes of Asteraceae (formerly Compositae) is provided. Each tribe is illustrated with a full page drawing of the inflorescence of a representative species.

The book is not limited to application in British Columbia. All of the Senecioneae of Alberta appear to be covered at the species level, though there may be some Alberta sub-species or varieties missing, and the descriptions generally reflect greater variation in appearance, especially size, than do the descriptions in Packer's revision of the Flora of Alberta. Two descriptions are given for each plant. One emphasizes the distinctive features of the plant, its habitat, and range, and will mention uses, ease of cultivation, and other interesting points as applicable. The second description is technical, and is generally more detailed than the description given by Packer for the same species.

The book is bound as a paperback 195 × 265 × 10 mm in size; this makes it a little fragile and cumbersome for use in the field. Since the ranges of many species are rather limited, the maps will be helpful, although, as the author cautions, they also represent the distribution of collectors. Because of this, and because they are limited to verified herbarium specimens, they show more limited distributions than actually occur. The maps frequently include distributions in areas adjacent to British Columbia, including parts of Alberta and the Yukon, for species whose distributions just spill over the border, rather than those which are widely distributed. A map of collected areas in British Columbia is included in the introduction.

The clear line drawings should be most helpful in determining species in this often difficult group. They generally show the whole plant, including the root system, usually at time of flowering. Details show the involucre, the mature achenes and pappus, and

sometimes a floret drawn to larger scale. In cases where the distinctions between taxa involve only a part of the plant, two or three subspecies or varieties are covered by a single illustration, with insets showing the differences. Since some of the drawings appear to be of herbarium specimens, mental adaptation may be needed when comparing them with live plants. The inflorescence, in particular, is likely to be distorted due to flattening and the development of achenes during drying. Compare the line drawing of *Senecio vulgaris* with a live specimen for an example.

Some of the taxa included are described as poorly defined; these account for the lack of any distinction in the illustration of *Senecio integerrimus* between var. *exaltatus* and var. *ochroleucus*, and the lack of range map or illustration for *Arnica cordifolia* var. *pumila*. *Arnica chamissonis* ssp. *foliosa* is not illustrated, but is distinguished in the key.

The illustration of *Petasites frigidus* shows leaves for var. *nivalis* and var. *frigidus*, but does not identify the leaf for var. *palmaris*, although it is shown on the plant illustrated. In the illustration of *Senecio canus*, the rays appear to be atypically short for a plant in full flower. The distribution map entitled "Range of *Arnica longifolia* in Alberta and the USA", true to the title, shows no specimens in B.C.; does this mean that no herbarium specimens collected in B.C. were examined? "Range . . . in British Columbia, adjacent Alberta, and adjacent USA" would have been unambiguous, if still confusing. In the key to varieties of *Arnica latifolia* "Small plants 13 dm tall . . ." should evidently read "Small plants 1-3 dm tall . . .". These small errors do not detract from the overall value of the book.

This volume, and the remainder of the series, covering Astereae, Anthemideae, Cichoreae, Cynareae, Eupatorieae, Heliantheae, and Inuleae would undoubtedly be welcome additions to the bookshelves of all students of the family, amateur and professional alike.

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American Arctic Lichens 1. The Macrolichens

By John Thomson. 1984. Columbia University Press, New York. 504 pp., illus. U.S. \$55.00.

The first thing to say about *American Arctic*

Lichens is that this book is not, as one might expect from the title, just a reissue of Thomson's earlier work, *Lichens of the Alaskan Arctic Slope* (reviewed in *The*

Canadian Field-Naturalist 94: 350-351). Included between its covers are accounts, not only of Alaskan lichens, but of every species of foliose and fruticose lichen known to occur across the northern breadth of North America, with Greenland thrown in for good measure. What is more, most of the 340 species covered are not strictly arctic lichens at all, but boreal or even temperate lichens which just happen to range into the land beyond the trees. Somewhat paradoxically, then, this book with the yankee title is the nearest thing yet to a flora of the macrolichens of interior Canada. Its publication by any standard is an important event in the history of Canadian botany.

American Arctic Lichens opens with a brief introduction to the geology and climate of the North American north, followed by a useful, if somewhat schematic, discussion of lichen distribution and substrate ecology. A preliminary key then guides the user to genus, and is followed by 62 species keys, arranged alphabetically from *Actinogyra* to *Zahlbrucknerella*. Intercalated with these are species accounts providing much pertinent information on the synonymy, morphology, apothecial characters, chemistry, habitat, and distribution of the species included. A North American range map accompanies each account, and for two-thirds of the species black and white illustrations have been prepared.

For whom is this book intended? Apparently the publisher had in mind the amateur — witness the glossy pages, the lush illustrations and the elegant layout. Thomson himself, however, appears to have been writing more for his colleagues in lichenology — who doubtless will not balk, as the amateur will, at his failure to include either an introduction to lichen structure or, for that matter, a glossary of technical terms.

The naturalist will therefore have to accept that, despite appearances, *American Arctic Lichens* is at base a technical guide. In many places, for instance, the keys will simply not work for him. Thus, in order to distinguish *Pannaria* and *Parmeliella* on the one hand from *Lobaria*, *Solorina* and *Peltigera* on the other hand, he is needlessly required to examine spore structure — this in genera whose species are as often as not sterile! No less alienating is Thomson's habitual reliance on lichen chemistry as a source of key characters. True enough it is far easier to advance the absolutes of the microscopist and the biochemist than it is to come to terms with the variability of lichen growth form. Still, even the professional lichenologist could wish that Thomson had worked just a little harder on the preparation of his keys.

Fortunately, Thomson's descriptions of the species are far more serviceable. Notwithstanding that they seldom reveal any real effort to diagnose consistently

for the same characters, they are at least usually adequate to express the main points of difference between related species. It would have been helpful, of course, if the author had taken greater care to emphasize which characters are the diagnostic ones; as it is, the user will often find it necessary to do considerable cross-checking before he is satisfied he knows how species X is supposed to differ from species Y.

Even so, any slack in the descriptions is usually taken up by the splendid illustrations which accompany them. For the naturalist, in fact, the illustrations are the book's major strength. Picture-keying (something naturalists usually excel in!) is therefore a real possibility with *American Arctic Lichens* — as with few other books in the field. Note however that the illustration of "*Peltigera horizontalis*" (p. 337) actually represents *P. elisabethae* (a species not recognized by Thomson), and that "*Cetraria commixta*" (p. 75) is really *C. hepatizon*, a species also illustrated on page 82.

On the negative side again, some mention must be made of the numerous errors and oversights which have inadvertently crept into the pages of this book. So pervasive are these, in fact, that it might be appropriate if the publisher prepared an errata slip for insert with future sales. Taking for example the account of the genus *Cetraria*, it is disturbing to note that thalline measurements have been omitted for about one-third of the nineteen species discussed. Also worrisome is the fact that of the combined 95 spot test reactions which might have been reported for the members of this genus, only 78 are listed: omitted, moreover, are no fewer than fifteen reactions which Thomson elsewhere uses as key characters! Other slips include the following: 1) *Cetraria laevigata*, containing fumarprotocetraric acid, gives a KC-reaction, not a KC+ yellow-to-red one, as reported; 2) *C. commixta*, with alpha-collatolic acid, and 3) *C. fastigiata*, with gyrophoric and hiascinic acids, both yield KC+ reactions, not KC-; 4) *C. pinastri* contains usnic acid and so yields not a KC- reaction, as reported, but a KC+ yellow one (which may admittedly be difficult to detect); 5) *C. nigricascens*, though stated in the keys to yield a K+ violet reaction in the epithecium, is not known to produce fruiting bodies according to the species account (actually apothecia do occur, but are rare, making this a poor species character at best); and 6) no chemistry at all is listed under *C. tilesii*, though in fact, as mentioned in the keys, that species contains usnic, rangiformic and pinastric acids, and yields a KC+ yellow reaction.

From what has gone before it might be too easy to conclude that *American Arctic Lichens* is a shoddy work of little application to the Canadian naturalist.

Nothing, however, could be further from the truth. As I have already mentioned, this book is the single most important volume ever to appear on the macrolichens of interior Canada. As a repository of essential information on the subject, it will not soon be excelled. The range maps alone — though admittedly deficient in their representation of western collections — contain much valuable data available nowhere else. Used in conjunction with an introductory guide such

as Mason Hale's *How to Know the Lichens* (Wm. C. Brown Co., 1979), there is no reason why this volume should not stimulate the Canadian naturalist community to a new level of appreciation for the macrolichens.

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MISCELLANEOUS

Joseph Le Conte: Gentle Prophet of Evolution

By Lester D. Stephens. 1982. Louisiana State University Press, Baton Rouge. 340 pp., illus. U.S. \$22.50.

Joseph Le Conte (1823-1901) is little remembered today, but in his time he was regarded as a prominent evolutionary philosopher, natural historian, physiologist and geologist. He spent the major portion of his academic career (1869-1901) as a professor at the University of California at Berkeley. The Le Contes were a well-known family in 19th century natural science, Joseph's elder brother John (1818-1891) having been a natural historian, physicist, and twice president of the University of California, while their cousin John Eatton Le Conte (1784-1860) and the latter's son John Lawrence Le Conte (1825-1883) were naturalists and entomologists. John Lawrence was regarded as the foremost American student of Coleoptera of his day.

The author, chairman of the Department of History at the University of Georgia, has written a perceptive account of this significant figure. Stephens points out that Le Conte "began his career when breadth of knowledge was the hallmark of a learned man," but it ended when the modern era of specialization was well under way. As a result, he is not as well known to us as his notable contemporaries Louis Agassiz and Asa Gray. The Le Contes were in comfortable circumstances in their native Georgia before the Civil War. Interestingly, most of Joseph's preparatory training was received at the hands of Alexander Stephens, a college friend of another older brother and later the Vice President of the Confederacy during the Civil War. Both Joseph and his brother won medical degrees at the College of Physicians and Surgeons in New York City, generally regarded in the 1840s as the finest school of its type in the country. Despite some serious doubts as to the quality of the training he had received, Joseph briefly enjoyed a successful medical practice before determining that he preferred a scholarly life. He spent fourteen months studying with Louis Agassiz at Harvard and in the Florida Keys

before embarking on a teaching career in South Carolina in 1852. Save for the Civil War years, when he performed various medical service and chemical functions for the Confederacy, and several years of marking time following the war, he remained a teacher for the rest of his life.

Le Conte was a deeply religious man who had been strongly influenced by Agassiz. He was at first persuaded of the validity of his mentor's ideas on separate creationism. It took time for him to come to terms with evolutionary thought, which he then had to reconcile with his religious views. He ultimately discussed his theistic evolutionism in a book, *Evolution and Its Relation to Religious Thought* (1888), which enjoyed a critical success here and in Europe. Le Conte was essentially a neo-Lamarckian, who in social terms attempted a synthesis of Social and Reform Darwinism. He posited a "higher evolution, inherited from above," which was voluntary, rather than spontaneous. He argued that the object of education should be to "prepare for a worthy life." Inasmuch as there was a mutual relationship between the school, the college, and the university, all educational schemes were environmental tools which should lead to individual, and hence social improvement. Le Conte called for better, but not identical educational and employment opportunities for women, and in general for equivalency, but not equality of the sexes.

Le Conte was the first to write systematically in the subject of physiological optics in this hemisphere, having published the first textbook in the Americas in 1881. He was not, however, sufficiently familiar with developments in Germany, and his text, though successful, was soon out of date. He was a much beloved teacher at Berkeley, and in the field of geology, a compiler and synthesizer, rather than an original investigator. His tendency to universality relegated him to the "second echelon of capable scientists," though he might otherwise have achieved a

higher ranking. His election to the presidency of two major American scientific groups, the A.A.A.S. and the Geological Society of America, and to the vice presidency of the International Congress of Geologists in the 1890s testified to his standing as one of the "most capable and gifted scientists in the country."

Stephens' book is an instructive account of the training of a Southern scientist before the Civil War, and of his adjustment to changing circumstances in the latter third of the 19th century. It is also useful as

an introduction to the nature of scientific thought and instruction at Berkeley in its early years.

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The Life and Letters of Alexander Wilson

Edited by Clark Hunter. 1983. Memoirs Volume 154. American Philosophical Society, Philadelphia. xi + 456 pp., illus. U.S.\$50.

This handsome volume is the work of a Scottish author who has previously written a number of articles on Alexander Wilson (1766-1813), the Scottish-born poet, weaver, and peddler, who came to the United States in 1794 and spent much of the rest of his life writing the justly famous *American Ornithology*. Wilson's early years were often frustrating. He experienced a "series of financial troughs" and wrote poetry, some of it critical of local businessmen and their operations, which got him into serious legal difficulties. On several occasions, he was convicted of libel.

Hunter has not attempted a comprehensive biography of Wilson in this book. He states that several previous authors have generally done a thorough and accurate job. He has come up with a few corrections to the generally accepted facts of Wilson's career, and supplies a modest amount of new information, drawn from his study of the correspondence. One interesting note concerns the Rev. Dr. John Witherspoon, the Scotch Presbyterian dominie who baptized Wilson. Witherspoon subsequently emigrated to the American colonies, became President of the College of New Jersey (now Princeton University), and was later a signatory to the American Declaration of Independence.

Arriving in Philadelphia at the age of 28, Wilson supported himself for a time by weaving, peddling goods from door to door, and teaching school. He became a citizen in 1804. He developed an interest in American birds, encouraged by the old time Philadelphia naturalist William Bartram, and began studying them in the field. He sought to join the Lewis and Clark Expedition as a naturalist, but without success. When in 1806 he was named assistant editor

for *Rees New Cyclopaedia*, he quit schoolteaching and soon conceived the idea of a multi-volumed illustrated work on the birds of his adopted country for which he would provide the pictures. Wilson had no formal training in art, but he learned to draw acceptable representations of the birds he found in his wanderings, and produced the first volume of his *American Ornithology* in 1808. He hand colored over 4500 plates for a press run of 500 copies, and soon discovered that he would have to devote his full energies to the project if there was to be any chance of completing it. Eight volumes were published before his death from tuberculosis at age 47. The ninth and final volume was completed by his friend George Ord, a wealthy and eccentric businessman who had become devoted to Wilson. Wilson's pathbreaking volumes were consulted by ornithologists for some years thereafter, and there is evidence that John James Audubon later modelled some of his paintings of birds on Wilson's work.

Hunter's book consists of a short biography of 113 pages followed by 150 letters, making it the most complete edition of Wilson's letters yet published. The first letter dates from 1788, when Wilson was 21, and the last was written in July, 1813, a month prior to his death. The letters record the joys of discovery and the physical strains of his life, and shed considerable light on the circumstances and accomplishments of this major figure in early 19th century American natural science.

This is a delightful and informative work which should interest students of ornithology and natural history generally.

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NEW TITLES

Zoology

- Animal intelligence: insights into the animal mind.** 1986. Edited by R. J. Hoage and Larry Goldman. Smithsonian Institution Press, Washington. 200 pp., illus. U.S. \$10.95.
- Animal language.** 1985. By Michael Bright. Cornell University Press, Ithaca. 251 pp., illus. Cloth U.S. \$24.95; paper U.S. \$12.95.
- ***Aphid ecology.** 1985. By A. F. G. Dixon. Blackie, Glasgow. ix + 157 pp., illus. £17.50.
- †**The Atlantic Alcidae: the evolution, distribution, and biology of the auks inhabiting the Atlantic Ocean and adjacent water areas.** 1985. Edited by D. N. Nettleship and T. R. Birkhead. Academic Press, Orlando, Florida. xx + 574 pp., illus. Cloth U.S. \$40; paper U.S. \$19.95.
- The Atlantic salmon in the history of North America.** 1986. By R. W. Dunfield. Canadian Special Publication of Fisheries and Aquatic Sciences 80. Supply and Services Canada, Hull. 181 pp., illus. \$11.95.
- The atlas of breeding birds of Vermont.** 1985. Edited by Sarah B. Laughlin and Douglas P. Kibbe. University Press of New England, Hanover, New Hampshire. xxii + 456 pp., illus. U.S. \$45.
- ***Atlas of Trichoptera of the S. W. Pacific.** 1986. By Arturs Neboiss. Junk, Dordrecht, The Netherlands. viii + 286 pp. Dfl.200.
- The avifauna of central northeast Greenland, 73°15'N — 74°05'N, based on a visit to Myggbukta, May-July 1979.** 1986. By Magnus Elander and Sven Blomquist. Commission for Scientific Research in Greenland, Copenhagen. 48 pp., illus.
- Bachman's Warbler: a species in peril.** 1986. By Paul B. Hamel. Smithsonian Institution Press, Washington. 128 pp., illus. U.S. \$11.95.
- Biology of amphibians.** 1986. By William E. Duellman and Linda Trueb. McGraw-Hill, New York. xx + 670 pp., illus. U.S. \$40.
- †**Biology of new world *Microtus*.** 1985. Edited by Robert H. Tamarin. Special Publication No. 8. American Society of Mammalogists, c/o University of Minnesota Museum of Natural History, Minneapolis. xiii + 893 pp., illus. U.S. \$55.
- The biology of *Paramecium*.** 1985. By Ralph Wichterman. Second edition. Plenum, New York. c595 pp. U.S. \$89.50.
- ***The birds of Canada.** 1986. By W. E. Godfrey. Revised edition. National Museum of Natural Sciences, Ottawa. 595 pp., illus. + 74 plates. \$39.95.
- †**Birds of eucalypt forests and woodlands: ecology, conservation, management.** 1985. Edited by A. Keast, F. Recher, H. Ford, and D. Saunders. Surrey Beatty and Sons, Chipping Norton, Australia. 384 pp., illus. A\$47 + postage or U.S. \$43.
- ***Birds of New Guinea.** 1986. By Bruce M. Beehler, Thane K. Pratt, and Dale Zimmerman. Princeton University Press, Princeton. xiii + 293 pp., illus. + 55 plates. Cloth U.S. \$65; paper U.S. \$37.50.
- †**The butterflies of Costa Rica and their natural history: Papilionidae, Pieridae, Nymphalidae.** 1987. By Philip J. DeVries. Princeton University Press, Princeton. c300 pp., illus. + 51 plates. Cloth U.S. \$60; paper U.S. \$22.50.
- Earthworms: their ecology and relationship with soils and land use.** 1985. By Kenneth E. Lee. Academic Press, New York. 416 pp. U.S. \$65.
- Echinodermata.** 1985. Edited by Brendan F. Keegan and Brendan D. S. O'Connor. From a conference, Galway, Ireland, September, 1984. Balkema, Accord, Massachusetts. xviii + 662 pp., illus. U.S. \$40.00.
- †**Ecological aspects of social evolution: birds and mammals.** 1986. Edited by Daniel I. Rubenstein and Richard W. Wrangham. Princeton University Press, Princeton. c512 pp., illus. Cloth U.S. \$65; paper U.S. \$23.50.
- ***The ecological implications of body size.** 1986. By Robert Henry Peters. Cambridge University Press, New York. xii + 392 pp., illus. U.S. \$16.95.
- †**Ecology and evolution of Darwin's finches.** 1986. By Peter R. Grant. Princeton University Press, Princeton. c464 pp., illus. Cloth U.S. \$55; paper U.S. \$22.50.
- Ecology of mosquitoes.** 1985. Edited by L. P. Lounibos, J. R. Rey, and J. H. Frank. Proceedings of a workshop, Welaka, Florida, January, 1984. Florida Medical Entomology Laboratory, Vero Beach. xxii + 579 pp., illus. U.S. \$15.
- †**Eider ducks in Canada.** 1986. Edited by Austin Reed. Canadian Wildlife Service Report Series No. 47. Canadian Government Publishing Centre, Ottawa. 188 pp., illus. \$19.50 in Canada; \$23.40 elsewhere.
- ***The encyclopedia of birds.** 1985. Edited by Christopher Perrins and Alex L. A. Middleton. Facts on File, New York. 480 pp., illus. U.S. \$35.
- ***Eskimo Curlew: a vanishing species?** 1986. By J. B. Gollop, T. W. Berry, and E. H. Iversen. Special Publication No. 17. Saskatchewan Natural History Society, Regina. 160 pp., illus. \$9.

The evolution and ecology of armadillos, sloths, and vermilinguas. 1986. Edited by G. Gene Montgomery. Smithsonian Institution Press, Washington. 462 pp., illus. U.S. \$45.

Evolutionary relationships among rodents: an interdisciplinary analysis. 1985. Edited by W. Patrick Luckett and Jean-Louis Hartenberger. Proceedings of a workshop, Paris, 2-6 July, 1984. Plenum, New York. c716 pp. U.S. \$110.

Experimental behavioral ecology and sociobiology: in memoriam Karl von Frisch 1886-1982. 1985. Edited by Bert Holldobler and Martin Lindauer. From a symposium, Mainz, Germany, October, 1983. Sinauer, Sunderland, Massachusetts. xiv + 488 pp., illus. Cloth U.S. \$55; paper U.S. \$30.

†**A field guide to the birds of Hawaii and the tropical Pacific.** 1987. By H. Douglas Pratt, Philip L. Bruner, and Delwyn G. Berrett. Princeton University Press, Princeton. c640 pp., illus. + 45 plates. Cloth U.S. \$50; paper U.S. \$19.95.

***Flying squirrels: gliders in the dark.** 1985. By Nancy Wells-Gosling. Smithsonian Institution Press, Washington. 128 pp., illus. Cloth U.S. \$24.95; paper U.S. \$9.95.

†**Foraging theory.** 1987. By David W. Stephens and John R. Krebs. Princeton University Press, Princeton. c256 pp., illus. Cloth U.S. \$40; paper U.S. \$14.50.

†**Fur seals: maternal strategies on land and at sea.** 1986. By Roger L. Gentry and Gerald L. Kooyman. Princeton University Press, Princeton. xviii + 291 pp., illus. Cloth U.S. \$40; paper U.S. \$14.50.

The grizzlies of Mount McKinley. 1985. By Adolph Murie. University of Washington Press, Seattle. xviii + 251 pp., illus. U.S. \$9.95.

***A guide to the birds of Colombia.** 1986. By Steven L. Hilty and William L. Brown. Princeton University Press, Princeton. xii + 836 pp., illus. + 56 plates + maps. Cloth U.S. \$95; paper U.S. \$42.95.

Guide to the freshwater aquatic microdrile oligochaetes of North America. 1986. By R. O. Brinkhurst. Canadian Special Publication of Fisheries and Aquatic Sciences No. 84. Supply and Services Canada, Hull. 259 pp., illus. \$14.95.

Habitat selection in birds. 1985. Edited by Martin L. Cody. Academic Press, Orlando. xviii + 560 pp., illus. U.S. \$69.50.

The history of Greenland caribou. 1986. By Morten Meldgaard. Commission for Scientific Research in Greenland, Copenhagen. *In press*.

Honeybee ecology: a study of adaptation in social life. 1985. By Thomas D. Seeley. Princeton University Press, Princeton. x + 202 pp., illus. Cloth U.S. \$39.50; paper U.S. \$14.50.

***The inland fishes of New York State.** 1985. By C. Lavett Smith. New York State Department of Environmental Conservation, Albany. xi + 522 pp., illus. U.S. \$29.95.

Insect aging: strategies and mechanisms. 1986. Edited by K. -G. Collatz and R. S. Sohal. Springer-Verlag, New York. c260 pp., illus. U.S. \$45.

The insects and arachnids of Canada, part 13: the carrion beetles of Canada and Alaska (Coleoptera: Silphidae and Agyrtidae). 1985. By Robert S. Anderson and Stewart B. Peck. Agriculture Canada, Ottawa. 121 pp., illus. \$7.

†**Listening in the dark: the acoustic orientation of bats and man.** 1986. By Donald R. Griffin. Reissue of 1958 publication. Comstock (Cornell University Press), Ithaca. 464 pp., illus. U.S. \$17.50.

†**Mar: a glimpse into the natural life of a bird.** 1986. By Louise de Kiriline Lawrence. New edition of 1976 publication. Natural Heritage / Natural History, Toronto. 103 pp. \$8.95.

The natural history of badgers. 1986. By Earnest Neal. Facts on File, New York. 238 pp., illus. U.S. \$19.95.

***A pictorial guide to the birds of the Indian subcontinent.** 1983. By S. Ali and S. D. Ripley. Oxford University Press, Don Mills. 177 pp., illus. \$35.75.

Populations and breeding schedules of waders, Charadrii, in high arctic Greenland. 1985. By Hans Meltofte. Commission for Scientific Research in Greenland, Copenhagen. 43 pp., illus. Dkr. 74.

***Predator-prey relationships: perspectives and approaches from the study of lower vertebrates.** 1986. Edited by Martin E. Feder and George V. Lauder. University of Chicago Press, Chicago. x + 198 pp., illus. Cloth U.S. \$26; paper U.S. \$11.95.

Primate societies. 1986. Edited by Barbara B. Smutts, Dorothy L. Cheney, Robert M. Seyfarth, Richard W. Wrangham, and Thomas T. Struhsaker. University of Chicago Press, Chicago. c608 pp., illus. Cloth cU.S. \$60; paper cU.S. \$27.50.

†**Proceedings of the second international conference on Copepoda, Ottawa, 13-17 August 1984.** 1986. Edited by G. Schriever, H. K. Schminke, and C.-t. Shih. Syllogeus 58. National Museum of Natural Sciences, Ottawa. v + 662 pp., illus. Free.

***Shorebirds: an identification guide to the waders of the world.** 1986. By Peter Hayman, John Marchant, and

Tony Prater. Houghton, Mifflin, Boston. 412 pp., illus. + 88 plates. U.S. \$34.

†**The sparrowhawk.** 1986. By Jan Newton. Buteo Books, Vermillion, South Dakota. 396 pp., illus. U.S. \$35.

Spring migration of birds across the Greenland inland ice. 1986. By Thomas Alerstam et al. Commission for Scientific Research in Greenland. *In press*.

The statistics of natural selection on animal populations. 1985. By Bryan F. J. Manly. Chapman Hall (Methuen), New York. xvi + 484 pp., illus. U.S. \$55.

Systematics and biogeography of the longicorn beetle tribe Tmesisterini. 1984. By J. Linsley Gressitt. Bishop Museum Press, Honolulu. iv + 263 pp., illus. U.S. \$23.50.

†**A systematic study of recent bison, with particular consideration of the wood bison (*Bison bison athabascæ* Rhoads 1898).** 1986. By C. G. van Zyll de Jong. Publications in Natural Sciences No. 6. National Museum of Natural Sciences, Ottawa. viii + 69 pp., illus. Free.

The tanagers: natural history, distribution, and identification. 1986. By Morton L. and Phyllis R. Isler. Smithsonian Institution Press, Washington. 464 pp., illus. + plates. Cloth U.S. \$70; paper U.S. \$49.95.

The wolves of Mount McKinley. 1985. By Adolph Murie. University of Washington Press, Seattle. xx + 238 pp., illus. U.S. \$9.95.

Botany

†**The Agaricales (gilled fungi) of California: 1. Amanitaceae.** 1982. By Harry D. Thiers; **2. Cantharellaceae.** 1985. By Harry D. Thiers; **3. Gomphidiaceae.** 1985. By Harry D. Thiers; **4. Paxillaceae.** 1985. By Harry D. Thiers, and **5. Hygrophoraceae.** 1985. By David L. Largent. Series editor Harry D. Thiers. Mad River Press, Eureka, California. 53 pp. + plates. U.S. \$6.95; 34 pp. U.S. \$3.95; 20 pp. U.S. \$1.95; 9 pp. U.S. \$1.65; and 208 pp. U.S. \$11.95.

†**Amanita of North America.** 1986. By David T. Jenkins. Mad River Press, Eureka, California. v + 197 pp., illus. U.S. \$33.95.

Atlas of dinoflagellates: a scanning electron microscope survey. 1985. By John D. Dodge. Farrand Press, London, England. viii + 119 pp. U.S. \$24.50.

Biotechnology and ecology of pollen. 1983. Edited by D. L. Mulcahy, G. Bergamini Mulcahy, and E. Ottaiviano. Springer-Verlag, New York. c550 pp., illus. U.S. \$46.

†**Botanical illustration: preparation for publication.** 1986. By Noel H. Holmgren and Bobbi Angell. New York Botanical Garden, Bronx. 74 pp., illus. U.S. \$12 in the U.S.A.; U.S. \$13 elsewhere.

†**The European garden flora: a manual for the identification of plants cultivated in Europe, both out-of-doors and under**

glass; volume 1. Pteridophyta, Gymnospermae, Angiospermae — Monocotyledons (part I). 1986. Edited by S. M. Walters, A. Brady, C. D. Brickell, J. Cullen, P. S. Green, J. Lewis, V. A. Matthews, D. A. Webb, P. F. Yea, and J. C. M. Alexander. Cambridge University Press, New York. xv + 430 pp., illus. U.S. \$99.50.

Forest trees of Australia. 1984. By D. J. Boland et al. Fourth edition. Nelson (U.S. distributor ISBS, Beaverton, Oregon). xvi + 687 pp., illus. U.S. \$49.95.

Geological factors and the evolution of plants. 1985. Edited by Bruce H. Tiffrey. From a symposium, Montreal, 1982. Yale University Press, New Haven, Connecticut. viii + 294 pp., illus. U.S. \$25.

Green inheritance: the World Wildlife Fund book of plants. 1985. By Anthony Huxley. Anchor/Doubleday, Garden City, New York. 193 pp., illus. U.S. \$19.95.

Herbs, spices, and medicinal plants: recent advances in botany, horticulture, and pharmacology. 1986. Edited by Lyle E. Craker and James E. Simon. Oryx, Phoenix. viii + 359 pp., illus. U.S. \$55.

Illustrated moss flora of arctic North America and Greenland. 1. Polytrichaceae. 1985. Edited by Gert S. Mogensen. Commission for Scientific Research in Greenland, Copenhagen. c60 pp., illus. Dkr 91.

Illustrated moss flora of arctic North America and Greenland. 2. Sphagnaceae. 1986. Edited by Gert S. Mogensen. Commission for Scientific Research in Greenland, Copenhagen. 61 pp., illus.

***The lichen-forming fungi.** 1984. By David L. Hawksworth and David J. Hill. Blackie, Glasgow. viii + 158 pp., illus. Cloth £16.95; paper £7.95.

Lichen physiology and cell biology. 1985. Edited by D. H. Brown. Plenum, New York. xii + 362 pp., illus. U.S. \$59.50.

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***Plant biosystematics.** 1984. Edited by William F. Grant. From a symposium, Montreal, July 1983. Academic Press, Orlando, Florida. (Distributed in Canada by Harcourt Brace Jovanovich, Don Mills, Ontario). xvi + 647 pp., illus. \$64.50.

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FRANCIS R. COOK
Editor

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Cover: Belugas, *Delphinapterus leucas*, in Prince Regent Inlet, Northwest Territories, 14 August 1983 (Department of Fisheries and Oceans, aerial photograph taken at an altitude of 900 metres, Kodak 5 x 5 inch *Ektachrome* 200). See status report pp. 271-278.

The Canadian Field-Naturalist

Volume 101, Number 2

April-June 1987

A Preliminary Study of the Status of White-beaked Dolphins, *Lagenorhynchus albirostris*, and Other Small Cetaceans off the Coast of Labrador

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Alling, Abigail, and Hal P. Whitehead. 1987. A preliminary study of the status of White-beaked Dolphins, *Lagenorhynchus albirostris*, and other small cetaceans off the coast of Labrador. Canadian Field-Naturalist 101(2): 131-135.

A preliminary study of the status of the White-beaked Dolphin, *Lagenorhynchus albirostris*, and other small cetaceans off the southern coast of Labrador was made during the summer of 1982. Interviews were conducted in fishing communities along the coast, and an offshore survey was carried out from a 13 m ketch. There is a substantial hunt of White-beaked Dolphins in Labrador. Harbour Porpoises, *Phocoena phocoena*, are entrapped in salmon nets. Belugas, *Delphinapterus leucas*, are hunted, but the take seems insignificant. A population estimate of 3486 White-beaked Dolphins was obtained using strip census data taken during a two-week period in August. The distance surveyed covered an area within the 200 m depth contour between St. Anthony, Newfoundland, and Nain, Labrador.

Key Words: White-beaked Dolphins, *Lagenorhynchus albirostris*, Labrador, Beluga, *Delphinapterus leucas*, Harbour Porpoise, *Phocoena phocoena*, fishery, hunting, entrapment.

The status of the White-beaked Dolphin, *Lagenorhynchus albirostris*, off the coast of Labrador has not previously been investigated. Incidental sightings and strandings indicate that the White-beaked Dolphin is found along the Labrador coast primarily during the summer months (Leatherwood et al. 1976; Sergeant and Fisher 1957; Tomilin 1967). White-beaked Dolphins have been hunted in European waters and off Iceland and Newfoundland for many years, but the extent to which they are exploited off Labrador is unknown (Mitchell 1973; Sergeant and Fisher 1957). Brice-Bennett (1977) reported a small whale and dolphin fishery in northern Labrador which was a primary food source for the Inuit in the past, but the present status of the fishery is undefined.

With the advent of synthetic nets, the incidental catch of small cetaceans has become a world-wide problem. A report of an incidental take of dolphins and porpoises in nets off Red Bay, Labrador suggested that cetaceans might be entrapped in nets all along the coast (Mitchell 1981). The possibility of an intensive incidental take of dolphins in nets off Labrador and Newfoundland, coupled with a potential hunt of the species, was cause for concern. It

was felt that an assessment of the present status of the White-beaked Dolphin was urgently needed. In 1982 we made a two-month study to obtain information on the number of dolphins taken by fishermen and to estimate the population off Labrador.

Methods

A survey based on interviews with local fishermen concerning the incidental entrapment and hunting of small whales was completed in Labrador during July and August, 1982. The survey covered 28 harbors containing settlements spread along the coast from L'Anse au Clair (51°25'N, 57°10'W) to Nain (56°00'N, 61°45'W). Transportation along the coast was primarily on boats which were collecting the salmon catch and on public coastal boats. Fifty-four fishermen were interviewed, and each was asked to assess the number of dolphins, porpoises, or small whales caught per year in his net and to estimate the number of animals killed per year by all fishermen in his harbor.

A 13 m ketch, *Findrinny*, was also used to conduct an offshore sightings survey. To get an estimate of the distribution and numbers of White-beaked Dolphins off Labrador, we used a strip census methodology

(Eberhardt 1978), and sailed from the coast as far out as the 200 m depth contour (Figure 1). We made such transects along the coast (and back) between St. Anthony, Newfoundland (51°30'N, 55°28'W) and Nain, Labrador. The vessel left St. Anthony on 12 August 1982, and returned on 28 August 1982. One observer of a crew of four was on deck to keep watch at all times. With the onset of darkness, the boat was hove to or anchored in nearby coves. The survey was made under sail unless the ship's speed dropped below 2 knots, in which case the engine was used.

Results

Strip census data

Findrinny covered a total distance of 2517 km (1) off Labrador during the dolphin census. When we looked at the distribution of right angle distances between the transect line and sighting positions, it seemed that few dolphins were missed within 0.4 km (d) of the transect line and this, therefore, was chosen as the effective strip width. We saw 130 dolphins (n) within 0.4 km of the transect line. The area of the continental shelf off Labrador between 51°30'N, 55°28'W and 56°00'N, 61°45'W, which is less than 200 m deep (excluding Lake Melville) is 54 000 km² (A). Thus the population estimate for the number of dolphins inside the 200 m depth contour of the area surveyed was given by

$$A \times \frac{n}{2dl} = 3486 \text{ animals}$$

Based on 22 (N) individual sightings, a 95% confidence interval for this estimate was 2001 to 4971 animals. The confidence interval was calculated from:

$$A \times \frac{n}{2dl} \left(1 + \frac{2}{\sqrt{N}} \right), A \times \frac{n}{2dl} \left(1 - \frac{2}{\sqrt{N}} \right)$$

Since adequate field methods for estimating populations of oceanic dolphins have not yet been perfected, we stress that this population estimate must be viewed with caution. Methods for estimating the number of cetaceans from vessels have primarily focused on tagging or mark-recapture techniques (Jolly 1965; Jones 1977; Seber 1965), both of which were inappropriate given our resources. We had, of necessity, to limit our approach to a population estimate based on transects from our sailing vessel. Methods for conducting a census of whale populations using transects have been improved beyond the simple equation we used, but the adjustments which have to be made were applicable to the behavior of large whales (Whitehead 1982), and are not necessarily appropriate when considering schools of smaller delphinids.

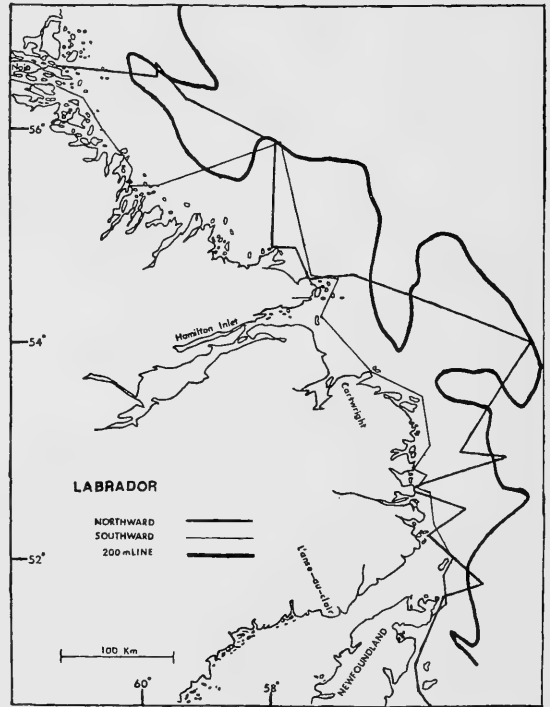


Figure 1. Northward and southward routes of the *Findrinny*, 12-28 August 1982, during which observations of White-beaked Dolphins and other small cetaceans were made (see text).

Double sighting is a problem with all census methodology. To decrease the chance of such an occurrence, we counted dolphin schools only as they passed abeam. Although this has been accepted as a method which decreases the chance of sighting large whales more than once, dolphins are more gregarious and frequently alter their speed of movement or direction (e.g. approaching or circling) when in the vicinity of boats. On the other hand, one must also consider the possibility that some schools of dolphins may have avoided *Findrinny*. (Presumably this would be particularly likely if they had recently been in the presence of hunters.) In either case, *Findrinny* could have altered the behavior of the dolphins, causing them to avoid or to approach the boat.

Although our estimate of 3486 animals off Labrador is plausible for August, it would represent an overestimate if dolphins approached our vessel or an underestimate if they avoided it (or were not counted within the strip). In addition, the behavior of White-beaked Dolphins and their distribution patterns may or may not be random. Our census might have been more accurate if there had been more time to take

stratified random samples based on depth contours (Eberhardt 1978; Gaskin 1982).

In August 1980, an aerial survey from a fixed wing aircraft in the coastal and offshore waters of eastern Newfoundland and southeastern Labrador produced an estimate of 5500 White-beaked Dolphins (Hay 1981). If, as the Labrador fishermen contend, the peak migration time for these dolphins off the Labrador coast occurs in September, then the 1980 and 1982 estimates would be roughly comparable. If White-beaked Dolphins travel north to Labrador in August, one might expect to find more White-beaked Dolphins off Newfoundland and southern Labrador in August than off northern Labrador.

Cetaceans taken or lost through hunting

According to our interviews with local fishermen, White-beaked Dolphins are first seen off the Labrador coast in late June. Hunting of cetaceans occurs primarily in August, September and October, and the animals are used for human consumption. The number of cetaceans taken by fishermen varies along the coast. The most active area for marine mammal hunts lies north of Hamilton Inlet. We found little or no evidence of hunting south of Hamilton Inlet except for harbors between Port Hope Simpson and Black Tickle. From the interviews, an estimated 366 dolphins are killed each year in 12 of the 28 harbors we visited.

The difference in hunting pressures between the areas north and south of Hamilton Inlet seems to be directly related to differences in food preferences in the ethnic groups which constitute the majority in the areas: Indians and Inuit in northern Labrador, and whites in southern Labrador. Hunting of small whales, dolphins or porpoises has been, and still is, a major source of food for the Inuit (Brice-Bennett 1977), whereas there is no documented dependence on cetaceans for food by whites. Discussions with fishermen in southern Labrador about hunting dolphins or porpoises varied with the individual. Some enjoyed hunting dolphins and traced their interest back to their forefathers, while others thought it was solely a practice of the past. Only one fisherman said he not only hunted dolphins, but Harbour Porpoise as well.

The technique used to hunt "Jumpers," the local name given to White-beaked Dolphins, seems to be the same in southern and northern Labrador. Usually .44 rifles are used to shoot an animal from a small outboard powered boat. The most effective location for crippling is behind the dorsal fin or on the lateral side of the body, but this is exceedingly difficult to achieve from a moving platform and with such a fast moving animal. As a result, many sink, if they are shot in the head, or escape, although wounded. Once

seriously maimed, however, the animal can be approached closely enough to be gaffed and brought on board the vessel. When asked about the success rate of killing and retrieving dolphins, fishermen answered that 25 to 50% of the animals which are killed are lost. Most fishermen agreed that if a rifle is accessible and dolphins come to "ride the bow" of their boats, they will shoot.

The hunting of Belugas, *Delphinapterus leucas*, is practiced north of Rigolet, but few of these animals are seen by the Inuit as far south as Makkovik. For the entire area from Makkovik to Nain, approximately six Belugas may be killed a year. Belugas may be entrapped in fishing gear, but all fishermen agreed that this seldom happens.

According to Brice-Bennett (1977), most of the Belugas are hunted north of Nain where they are more abundant. In winter, a small number of Belugas appear to move from the western coast of Greenland to the northern coast of Labrador and some whales possibly migrate between the Eastern Canadian Arctic and the Gulf of St. Lawrence (Gurevich 1980; Sergeant and Brodie 1975).

It seems probable that inshore, shallow water species such as the Beluga can be hunted successfully as they move south along the northern Labrador coast in the winter. Since Inuit hunt Belugas and Narwhals, *Monodon monoceros*, in areas north of Labrador in the Eastern Canadian Arctic (Finley et al. 1980; Kemper 1980), it is likely that similar hunting methods exist in northern Labrador.

Cetaceans taken incidentally in nets by fishermen

Most, if not all, of the incidental catch of cetaceans off Labrador consisted of Harbour Porpoise entrapment. We examined four dead Harbour Porpoises which had been taken from salmon nets. During our time in Labrador, no cetaceans were found in the gill nets set for cod and other bottom fish. Although the Harbour Porpoise is too small to escape from salmon nets, the larger dolphins apparently can avoid or break through salmon nets but not the stronger gill nets set for other species of fish (Ohsumi 1975).

In the 28 harbours where interviews were conducted, the average number of animals entrapped per harbor is four per year. There are 80 harbours with registered fishermen in Labrador. With an average of four animals caught as a by-catch per harbour, an estimate of 320 animals may be entrapped each year along the coast.

Mitchell (1980) interviewed Fishermen in Red Bay, Labrador, and found that 1 to 3 porpoises and 1 to 3 dolphins were caught each year in salmon nets and cod traps. The porpoise is an inshore, shallow water species, while the White-beaked Dolphin is primarily an offshore migratory species (Gaskin 19874; Leather-

wood et al. 1976). Since cod traps are set in shallow water, they would most likely catch porpoises but not the White-beaked Dolphin and, as stated above, the salmon nets usually do indeed only catch porpoises. Also, we found that the fishermen were able to identify different species of cetaceans when the animals were alive, but when the animals were dead, they confused the Harbour Porpoise with the White-beaked Dolphin. All four Harbour Porpoises which we examined were initially identified as dolphins by the fishermen. Based on these observations, we have reason to doubt that dolphins are actually caught and suggest that 2 to 6 Harbour Porpoises are taken per year (average 4) in Red Bay.

Conclusion

Using the population estimate of 3486 White-beaked Dolphins off Labrador, 366 dolphins taken in only 12 harbors represents 10.5% of the dolphin population. This does not include the take in other harbours, animals killed and lost, or possible entrapments. Studies have suggested that a population of baleen whales can sustain a harvest of 5 to 10% per year (Gulland 1975). A take of dolphins by Labrador fishermen, which may be considerably higher than 10.5% of the population could, therefore, threaten the population in the future.

This survey should be viewed as a preliminary study. Until the catch is effectively monitored in Labrador and Newfoundland and the population estimates are improved, the status of the White-beaked Dolphin will remain in question. We recommend that regular monitoring of the intentional and unintentional take of small cetaceans (particularly White-beaked Dolphins, Harbour Porpoises and Belugas) in Labrador should be given a high priority.

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Literature Cited

- Brice-Bennett, C. 1977. Our footprints are everywhere. Dolco Printing Ltd, Canada. 38 pp.
- Eberhardt, L. L. 1978. Transect methods for population studies. *Journal of Wildlife Management* 42(1): 1-31.
- Finley, K. J., R. A. Davis, and H. B. Silverman. 1980. Aspects of the narwhal hunt in the Eastern Canadian Arctic. Report of the International Whaling Commission 30: 459-464.
- Gaskin, D. E. 1974. *Phocoena phocoena*. *Mammalian Species* 42: 247-346.
- Gaskin, D. E. 1982. The ecology of whales and dolphins. Heinemann Ltd, London. 459 pp.
- Gulland, J. A. 1975. Distribution and abundance of whales in relation to basic productivity. Pp. 27-52 in: The whale problem Edited by W. E. Schevill. Harvard University Press, Cambridge.
- Gurevich, V. S. 1980. Worldwide distribution and migration patterns of the white whales, *Delphinapterus leucas*. Report of the International Whaling Commission 30: 465-480.
- Hay, K. 1981. Line-transect estimates of whale abundance in the Newfoundland-Labrador area, 1980. Report to the Canadian Atlantic Fisheries Advisory Committee. 36 pp.
- Jolly, G. M. 1965. Explicit estimates from capture-recapture data with birth, death and immigration — stochastic model. *Biometrika* 52: 225-247.
- Jones, R. 1977. Tagging: Theoretical methods and practical difficulties. Pp. 46-66 in *Fish population dynamics*. Edited by J. A. Gulland. John Wiley, London.
- Kemper, J. B. 1980. History of use of narwhal and beluga by Inuit in the Canadian Eastern Arctic including changes in hunting methods and regulations. Report of the International Whaling Commission 30: 481-492.
- Leatherwood, S., D. K. Caldwell, and H. E. Winn. 1976. Whales, dolphins and porpoises of the Western North Atlantic. A guide to their identification. NOAA Technical Report NMFS circ-396, Seattle, Washington. 176 pp.
- Mitchell, D. E. 1975. Porpoise, dolphin and small whale fisheries of the world. IUCN Monograph 3, International Union of Nature and Natural Resources, Morges, Switzerland. 129 pp.
- Mitchell, D. E. 1975. Report of the meeting on smaller cetaceans, Montreal, April 11, 1974. *Journal of the Fisheries Research Board of Canada* 32(7): 889-983.
- Mitchell, D. E. 1981. Canada progress report on cetacean research June 1979-May 1980. Report of the International Whaling Commission 31: 171-179.
- Ohsumi, S. 1975. Incidental catch of cetaceans with salmon gillnet. *Journal of the Fisheries Research Board of Canada* 32(7): 1229-1235.
- Seber, G. A. F. 1965. A note on the multiple-recapture census. *Biometrika* 54: 249-259.
- Sergeant, D. E. 1961. Whales and dolphins of the Canadian East Coast. Fisheries Research Board of Canada, Arctic Unit, circ (7). 77 pp. and record sheets.
- Sergeant, D. E., and H. D. Fisher. 1957. The smaller Cetacea of Eastern Canadian waters. *Journal of the Fisheries Research Board of Canada* 14: 83-115.
- Sergeant, D. E., A. W. Mansfield, and B. Beck. 1970. Inshore records of cetacea for Eastern Canada, 1949-68. *Journal of the Fisheries Research Board of Canada* 27: 1903-1915.

- Sergeant, D. E., and P. F. Brodie.** 1975. Identity, abundance and present status of populations of white whales, *Delphinapterus leucas*, in North America. *Journal of the Fisheries Research Board of Canada* 32(7): 1047-1054.
- Sergeant, D. E., D. J. Aubin, and J. R. Geraci.** 1980. Life history and Northwest Atlantic status of the Atlantic white-sided dolphin, *Lagenorhynchus acutus*. *Cetology* 37. 12 pp.
- Tomilin, A. G.** 1967. Mammals of the USSR and adjacent countries. Israel Program for Scientific Translations, Jerusalem. 717 pp.
- Whitehead, H.** 1982. Populations of humpback whales in the Northwest Atlantic. Report of the International Whaling Commission 32: 345-353.

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Movements of Radio-tagged Bald Eagles, *Haliaeetus leucocephalus*, in and from Southeastern Alaska

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Thirty-one Bald Eagles were radio-tagged on the Chilkat River, Alaska, from 1979 through 1982. After departing in early winter, all eagles moved southward into the northern panhandle region of Alaska. Adults and subadults remained there through the breeding season. Of the first-year and immature eagles, an estimated 73% continued further south through the winter season into coastal British Columbia and Washington. Only 2 of 15 first-year and immature eagles returned to southeast Alaska or the Chilkat River the following summer or fall.

Key Words: Bald Eagle, *Haliaeetus leucocephalus*, telemetry, movement, Alaska, British Columbia, capture.

Bald Eagles, *Haliaeetus leucocephalus*, are known to use north-south migration routes from nesting grounds in interior Canada to wintering areas in the continental United States (Young 1983; Gerrard et al. 1978). Migratory movements along the Pacific coast have been proposed (Servheen and English 1979) but as yet have not been adequately documented.

Our capture efforts were directed towards the Bald Eagles concentrated along the Chilkat River located at the northern extreme of the southeast panhandle of Alaska. As many as 4000 Bald Eagles gathered annually from October through January to feed on a unique late spawning run of Chum, *Oncorhynchus keta*, and Coho Salmon, *O. kisutch*. This unusual phenomenon became the subject of multidisciplinary research on eagles, fisheries, timber, soils, and hydrology. Planned timber and mining developments posed potential threats to the Chilkat River Bald Eagle concentration, and movement studies were needed to determine the regional and international significance of this concentration. The objectives of the Bald Eagle migration studies were to determine 1) movements of Chilkat River eagles when salmon become unavailable, 2) breeding grounds of eagles using the Chilkat River, and 3) seasonal movements of immature eagles.

Methods

Eagles were captured using several methods. Padded steel traps, similar to those used by Young (1983), around a staked salmon carcass were used in above-freezing temperatures and turbid water conditions. Monofilament snares attached to floating fish were used to catch eagles along open water areas.

Perch snares were useful on river sandbars in areas with high numbers of feeding eagles.

Most of the eagles were captured using the perch snare (Figure 1). Perches were constructed from limbs, typically 2 m long. A short 0.25 m section of the limb extended horizontally at 90° to the long section (Figure 1). The short section was attached with a hinge. The weight of a landing eagle countered a spring opposite the hinge causing the short section to rotate downward, releasing the spring-powered snare and closing the noose rapidly.

Nest trees were climbed to capture and radio-tag eagles at approximately nine weeks of age. Harnesses were loosely attached to accommodate normal growth and weight gain.

Transmitters (Telonics, Inc., Phoenix, Arizona) weighed 55 g and were hermetically sealed. Radios were attached to eagles with a two-strand backpack harness which crossed over the bird's upper breast. Transmitter life varied from 10 to 15 months. Cotton string was used to attach the harness to the transmitter and was expected to disintegrate and release the package from the eagle after the transmitter life had ended.

Radio-tagged eagles were tracked with a modified turbo-prop DeHavilland Beaver flown at an elevation of 2400 m. A two-element antenna was positioned on the strut under each wing to provide maximum reception perpendicular to the direction of flight. Reception distance of signals varied from 30 to 120 km. A typical reconnaissance flight covering the 100 000 km² area of southeast Alaska required 5.5 hours flight time at a ground speed of 240 km/h. Flights were attempted monthly. Each year during

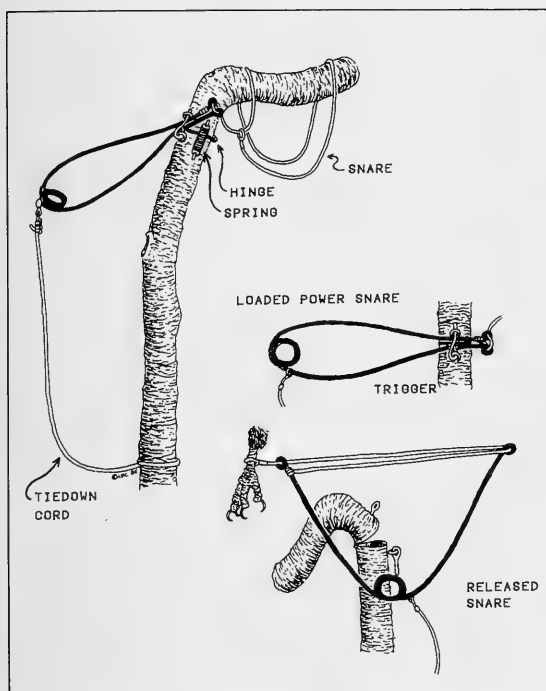


FIGURE 1. Perch snare used for capturing Bald Eagles on the Chilkat River.

March, one flight was made covering the coast from the Chilkat River to Washington.

First-year birds were defined as fledglings caught in the fall of their hatching year. Immature birds were more than 6 months old but were too young to have a predominantly white head and tail. Subadult birds had a predominantly white head and tail with the presence of a dark eye-stripe or traces remaining of the eye-stripe. Adult birds had all-white head and tail.

Results

Most of the eagles radio-tagged on the Chilkat River were captured with the perch snare. It was equally effective for all age classes. The maximum capture rate was one caught for every three strikes. This technique may require a large concentration of eagles as a prerequisite since a capture is dependent upon the chance alighting of an eagle on the artificial perches.

Thirty-one bald eagles were radio-tagged on the Chilkat River during the fall concentrations of 1979 through 1982: 8 first-year birds, 7 immatures, 2 subadults, and 14 adults. Tagged birds generally departed from the Chilkat River concurrent with major out-migrations of unmarked eagles. Of 21

eagles radio-tagged prior to 31 October, eight left in November, nine in December, and four in January.

Two passes with the aircraft at high altitude over the 160-km-wide coastal archipelago provided nearly complete coverage. A reconnaissance flight during 23 to 26 March 1982 from the Chilkat River to Washington and return serves as an example. We were searching for 13 radio-tagged eagles that had departed from the Chilkat River. Twelve were located during the flight: eight in southeast Alaska, three in British Columbia, and one in Washington. The thirteenth eagle was located one month later in southeast Alaska.

Outward Migration

Relocations of first-year and immature eagles indicated dispersal southward along the coast from Alaska through British Columbia to Washington (Figure 2). The southernmost record was from a first-year bird that left the Chilkat River on 29 November and was found dead 57 days later on the southwest coast of Washington, 1500 km distant. Of the 15 radio-tagged first-year and immature eagles, 27% remained in southeast Alaska throughout the summer. We estimate that the other 73% moved on into British Columbia or farther south.

The 16 subadult and adult eagles had movement patterns that differed from the younger birds (Figure 3). Their movements were restricted to the northern panhandle of Alaska, less than 320 km south of the Chilkat River. One adult strayed an additional 160 km south for a brief period in March and then returned north.

Two adults were recorded in early May at another large eagle concentration on the Stikine River delta where 1000 to 1500 eagles gather annually to feed on spawning Eulachon, *Thaleichthys pacificus*. Relocations of those adults indicated that they spent the remainder of the nesting season at specific areas, possibly nesting territories, 160 and 270 km northwest of the Stikine River.

Only 2 of 15 (13%) first-year or immature eagles returned to the Chilkat River the following fall with operating radio transmitters, whereas 4 of 16 (25%) adults or subadults returned. The actual return rates for both age classes were no doubt higher than our results show because of transmitter loss or transmitter failure from expired batteries.

Three fledglings were radio-tagged at nests on the Chilkat River. All three remained on the river into December before departing southward.

Breeding

Of the ten adults known to have operating transmitters during the breeding season, three remained within 50 km of a specific location and may

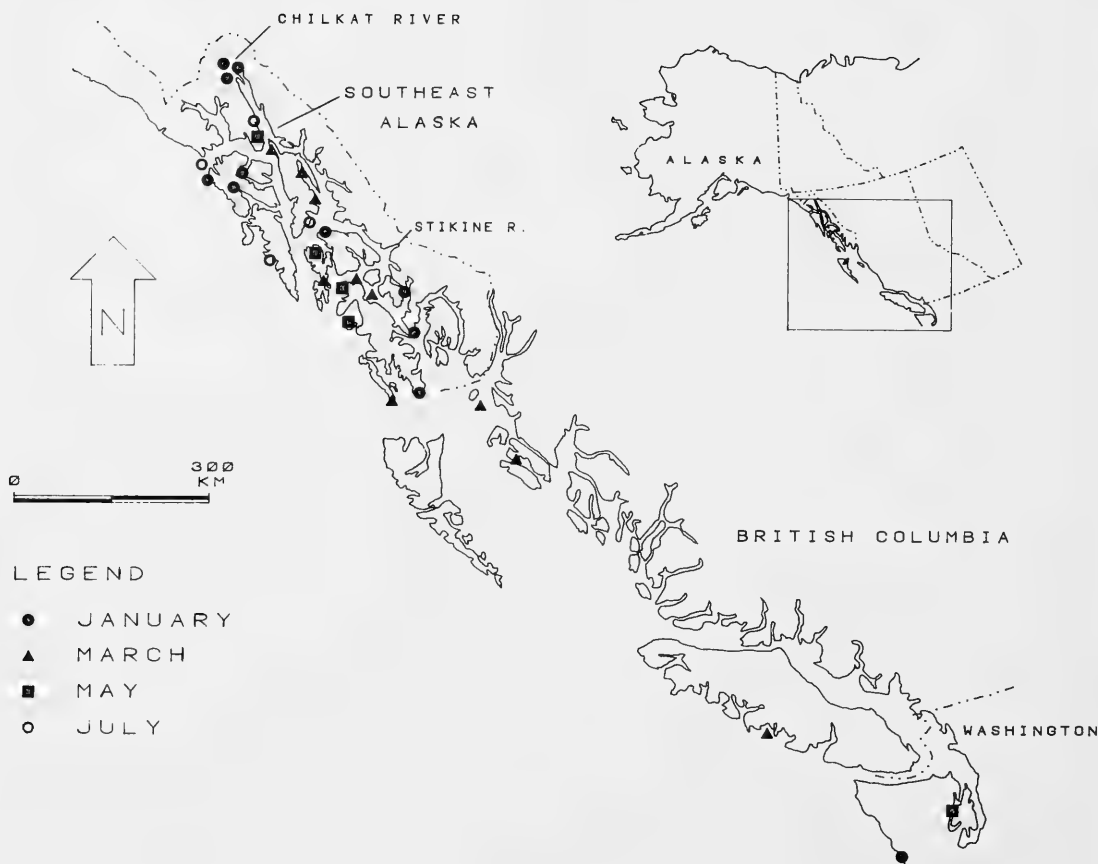


FIGURE 2. Relocation points of first-year and immature Bald Eagles radio-tagged on the Chilkat River in late fall and early winter of 1979, 1980, 1981, and 1982. Some points represent more than one relocation for a single individual.

have bred, although ground surveys were not conducted to verify breeding. The remaining seven adults probably did not nest, as they made widespread movements during the breeding season.

Detailed ground observations including 12 visual sightings were made on an eagle throughout the breeding season. The eagle remained within 15 km (usually 0.25 km) of a specific location for the entire period. The eagle had subadult plumage when marked the previous fall and full adult plumage by the following breeding season. It was occasionally seen perched within 2 m of another adult. There were no known nests in the immediate area.

Inward Migration

Only one of four adults radio-tagged in southeast Alaska during the breeding season moved to the Chilkat River concentration the following fall. That

adult interrupted its 22 October to 30 November stay at Chilkat River with a five-day return visit to its nest site in mid-November. The only fledgling radio-tagged in northern southeast Alaska moved about 130 km to the Chilkat River the following fall.

None of the five eagles radio-tagged away from the coast used the Chilkat River. These included one fledgling and one adult radio-tagged near Whitehorse in Yukon Territory, and three fledglings radio-tagged near Fairbanks, Alaska. The fledgling marked at Whitehorse was relocated in March of the following year on the north shore of the Olympic Peninsula, Washington.

Mortality

First-year birds had a much higher known mortality rate than older birds ($p < 0.05$, binomial) even though their travel farther from the study area



FIGURE 3. Relocation points of subadult and adult Bald Eagles radio-tagged on the Chilkat River in late fall and early winter of 1979, 1980, 1981, and 1982. Some points represent more than one relocation for a single individual.

resulted in a lower likelihood of their being recovered by the researchers (Table 1). The four recoveries of first-year birds were 290, 480, 1250 and 1500 km southeast from the Chilkat River. A subadult and an adult were each recovered about 160 km southeast of the Chilkat River.

The cause of death could not be determined in most instances because the carcasses were not recovered before they had become well decomposed. The first-year bird recovered in Washington was partially covered with oil and had washed up on the beach along with several oiled seabirds.

Discussion

As the availability of salmon to Bald Eagles decreased during early winter on the Chilkat River, either because of severe ice buildup on the river's edge

in cold weather or because of the declining salmon run, the Bald Eagles departed from the valley. They moved initially into the northern half of the panhandle of Alaska. Adults and subadults remained at this area while immatures and fledglings continued to disperse in a southward direction. More than half of the younger birds were assumed to have moved into British Columbia or Washington by spring.

Breeding-age eagles at the Chilkat River concentration appeared to represent coastal Bald Eagles of southeast Alaska. Hodges and King (1979) estimated 7300 adults in southeast Alaska or 0.9 adults/km of shoreline. That source is large enough to account for the 2700 adults found on the Chilkat River in fall.

Adult eagles migrated only short distances southward during winter. Because breeding densities are at or near saturation in southeast Alaska, it may be

TABLE 1. Known mortality of Bald Eagles radio-tagged on the Chilkat River.

	First Year	Immature	Subadult	Adult	Total
Eagles radio-tagged	8	7	2	14	31
No. found dead	4	0	1	1	6
Percentage found dead	50	0	50	7	19

necessary for adults to remain there through the winter to retain possession of their nesting territories or to be in a position to move into a vacant territory. Young eagles, less adept at competing for available food, are free to move into British Columbia or Washington where the climate is warmer and food may be more abundant. However, eagles migrating into coastal British Columbia must also compete with a large resident population of eagles, numbering 9000 adults (Hodges et al. 1984).

The first-year birds at Chilkat River are assumed to be from nests in southeast Alaska. Additional marking of fledglings would help to substantiate that assumption. The natal area for immature eagles that use the Chilkat River is probably also southeast Alaska, but that is unproven.

We hypothesize the following migration patterns of Bald Eagles on the Pacific coast from Chilkat River to Washington. Adults, especially breeders with territories, may be resident. However, adults will move up to 300 km to an abundant food source such as salmon, Eulachon, or Pacific Herring, *Clupea harengus pallasii*, runs. Shortly after fledging, young eagles move from the nest to a nearby food source, usually a salmon run. As salmon runs decline through the fall or early winter the immature eagles shift in a southerly direction, some migrating much farther than others. The farthest movement noted for immatures from Chilkat River was to the southern Washington coast.

This agrees well with the suggestions by Servheen and English (1979) with the exception that we cannot substantiate any westerly movement of eagles from the interior of northern British Columbia into southeast Alaska. The major migration route of those eagles may remain east of the coastal mountain range through British Columbia.

We did not obtain data to support a northern shift of immatures during the spring and summer, although such movement is likely. Eagles radio-tagged on the Skagit and Nooksak rivers of northern Washington showed a greater tendency to migrate inland up the major rivers rather than northward along the coast. Those eagles may represent interior rather than coastal populations.

The lower percentage of first-year and immature birds than of adults returning to the Chilkat River the

next year could reflect differential annual mortality rates for the two age-groups. It is possible that immature birds which overwinter in British Columbia and Washington may remain there for several years. If so, it would be important to know how many of those young birds return to southeast Alaska to breed and how many remain in British Columbia or Washington to breed.

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Literature Cited

- Hodges, J. I., and J. G. King. 1979. Resurvey of the bald eagle breeding population in southeast Alaska. *Journal of Wildlife Management* 43: 219-221.
- Hodges, J. I., J. G. King, and R. Davies. 1984. Bald eagle breeding population survey of coastal British Columbia. *Journal of Wildlife Management* 48: 993-998.
- Hunt, W. G., and B. S. Johnson. 1981. Impacts of a proposed Copper Creek dam on bald eagles: second winter study. *Biosystems Analysis Report*, 37 Clementina Street, San Francisco, California 94105. 113 pp.
- Servheen, C. W., and W. English. 1979. Movements of rehabilitated bald eagles and proposed seasonal movement patterns of bald eagles in the Pacific Northwest. *Raptor Research* 13: 79-88.
- Young, L. S. 1983. Movements of bald eagles associated with autumn concentrations in Glacier National Park. M.Sc. thesis, University of Montana, Missoula, Montana. 102 pp.

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Polar Bear, *Ursus maritimus*, Predation on Belugas, *Delphinapterus leucas*, in the Bering and Chukchi Seas

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Lowry, Lloyd F., John J. Burns, and Robert R. Nelson. 1987. Polar Bear, *Ursus maritimus*, predation on Belugas, *Delphinapterus leucas*, in the Bering and Chukchi seas. *Canadian Field-Naturalist* 101(2): 141–146.

Two incidents of Polar Bear predation on Belugas which occurred off the coast of western Alaska in April 1984 are described. A single subadult Beluga was killed at a small lead in the Chukchi Sea, probably by a female bear with three cubs, and at least 40 whales were killed at an ice entrapment by one or more bears in the northern Bering Sea. A review of such occurrences off Alaska, Canada, and Eurasia indicates that Belugas are normal prey of Polar Bears. Bear predation may occur when whales are entrapped by ice or while unrestrained whales are passing through leads or surfacing at holes in deteriorating ice sheets. Bear predation probably has little effect on Beluga populations, although it may be of occasional significance at entrapments when many whales are killed that eventually would have been released. Belugas are large in comparison to other potential prey and may be of some local importance in Polar Bear diets.

Key Words: Polar Bear, *Ursus maritimus*, Beluga, *Delphinapterus leucas*, predation, Alaska.

Although it is generally recognized that Polar Bears, *Ursus maritimus*, may at times prey on Belugas (white whales), *Delphinapterus leucas* (e.g. Tomilin 1957; Kleinenberg et. al. 1964), there are no published records of such occurrences in the waters off Alaska. We present observations of Polar Bear predation on Beluga Whales in the Bering and Chukchi seas, describe the environmental circumstances surrounding the events, and discuss the possible significance of this phenomenon.

Observations

During spring of 1984, a marine mammal research program was conducted in the eastern Chukchi Sea near Cape Lisburne, Alaska. Field operations included helicopter flights over the shorefast ice, flaw zone, and drifting pack ice. Below-normal temperatures prevailed in the area throughout the first part of April. The low temperatures followed almost a month of above-normal temperatures and resulted in continual freezing of leads. On 24 April open water areas appeared in the flaw zone and rapidly developed into an extensive lead system. Hundreds of Belugas were seen moving northward through the leads from 25 to 27 April. The leads were again mostly refrozen from 29 April to 3 May. During this period whales were occasionally sighted in small cracks and under thin ice. Impressions of Belugas, made when thin ice formed over the backs of stationary whales, were seen throughout the flaw zone. The leads reopened on 4 May and Belugas were seen moving northward from then until our observations ended on 13 May.

During a flight over the flaw zone on 27 April, we sighted a female Polar Bear accompanied by three one-year-old cubs. Blood was evident on the cubs' fur, so we circled to examine the area. A large Polar Bear was feeding on the carcass of a Beluga about 300 meters from the sow and cubs. We landed and examined the carcass and kill site (68°54.9'N, 166°48.5'W).

The carcass was on a large piece of thick ice that formed one edge of a lead that had numerous medium-sized floes adrift in it (Figure 1). With the exception of some very small openings, the area between the floes was filled with thin ice and slush. An obvious trail of blood led from the carcass to the edge of the lead where it ended in slush ice. It was unclear exactly where the kill had been made. However, when we later searched the area from the air, we located a patch of blood-stained snow and numerous bear tracks on a floe that was drifting slowly up the lead, about 150 meters from where the blood trail ended. The bear had apparently caught the whale from the drifting ice when the floe was against the edge of the lead, pulled the whale onto the floe, then dragged it onto the more stable ice.

The carcass was that of a young Beluga (standard length 230 cm), probably 2 years old. The skin and blubber had been entirely removed from the head and torso but was still intact on the flukes. A detached section of skin (about 60 by 100 cm) was near the carcass. All of the blubber had been chewed or scraped off that piece of skin. The chest and abdominal cavities had been opened but all organs

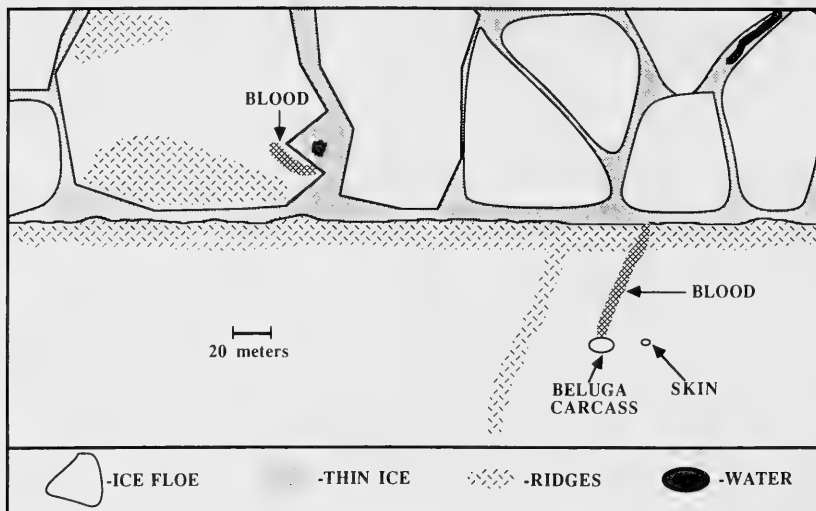


FIGURE 1. Diagram of the area where a Polar Bear killed a Beluga in the eastern Chukchi Sea, 27 April 1984.

were intact. Both front flippers and some ribs were missing, and the muscle of the axial skeleton had been removed to the bone. The lower jaw was broken. The carcass was not frozen although the air temperature at the time was -10°C .

The second instance of predation also occurred in the spring of 1984. Bears and dead whales were first seen and photographed on 24 April from an airplane flying just south of Bering Strait, between Fairway Rock and Little Diomed Island (approximate location $65^{\circ}41.5'\text{N}$, $168^{\circ}45.0'\text{W}$). At that time it was reported that there were 15 Polar Bears and a large number of carcasses longer than 2 meters spread around a hole in the ice (John Fray, personal communication). A diagram of the situation was constructed from photographs (Figure 2). It was difficult to identify all Beluga carcasses because many were partially covered by drifting snow or obscured by ice ridges. Nevertheless, counts indicated a minimum of 40 Belugas on the ice, and an additional 12 to 15 possible carcasses. Most of the carcasses had been fed upon only minimally, and appeared to be of gray, subadult animals. Five bears visible in the photographs were all medium to large animals. The pilot reported that at the time of the sighting there were numerous leads nearby, and open water was visible in the photographs at a distance of about 1 km.

The kill site was observed again on 6 May by residents of Little Diomed Island (Little Sister Joseph Alice, personal communication). By that time the ice had drifted to a location about 4 km north of

Little Diomed (approximate position $65^{\circ}48.2'\text{N}$, $168^{\circ}54.0'\text{W}$). An estimated 30 Polar Bears were scavenging carcasses of Belugas that were scattered around the opening in the ice.

We also received reports of Polar Bear predation on Belugas in the southern Chukchi Sea in April 1984, but we were unable to document the circumstances through personal examination or photographs. The first report was from people snowmachining in the vicinity of Cape Thompson ($68^{\circ}08'\text{N}$, $166^{\circ}00'\text{W}$) who saw where Polar Bears had killed "at least" one Beluga (Roland Quimby, personal communication). The second report was from a pilot (David Furber, personal communication), who reported seeing numerous Belugas in two small holes in an area of extensive refrozen leads (approximate position $67^{\circ}49'\text{N}$, $165^{\circ}15'\text{W}$). Several Polar Bears and several dead Belugas were on the ice nearby.

Discussion

Prior to 1984 we received few reports of Polar Bear predation on Belugas in the Bering and eastern Chukchi seas. On 26 March 1967, Robert Curtis saw a dead Beluga on the ice in the southern Chukchi Sea that he said had been caught and partially eaten by a Polar Bear (personal communication to Francis H. Fay). Nelson Walker, who for many years was engaged in guiding Polar Bear hunters in the central Chukchi, often saw small groups of Belugas entrapped by ice in the region west of 168°W longitude (personal communication). Bears hunted at

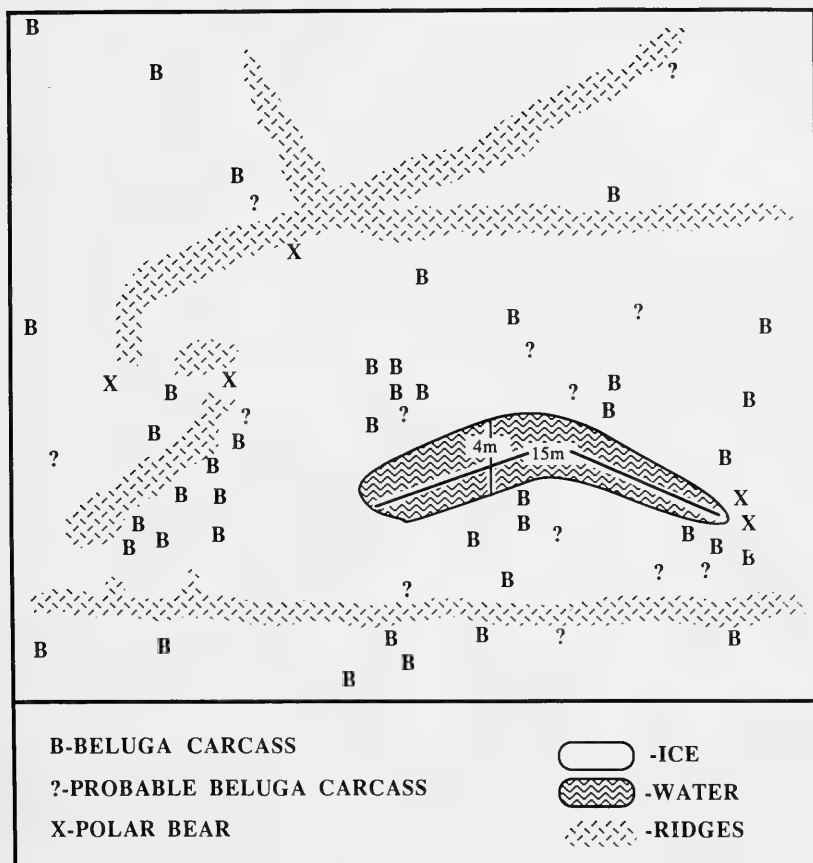


FIGURE 2. Diagram of the area where Polar Bears killed Belugas in the northern Bering Sea, April 1984.

many of the entrapments, and up to seven dead whales were seen. On 15 May 1979, in the northeastern Chukchi Sea near Point Barrow ($71^{\circ}01'N$, $157^{\circ}25'W$), Don K. Ljungblad (personal communication) saw four Polar Bears, two of which were feeding on a Beluga carcass, while a third was pulling a whale out of the water through very thin ice. The kills had been made at the north end of a narrow lead. An estimated 40 to 60 Belugas were milling about in a wider portion of the lead just to the south. Another occurrence was documented by a photograph in Mitchell and Reeves (1981) taken on 12 July 1975 in the Beaufort Sea approximately 110 km north of the Mackenzie River delta which shows a subadult Beluga lying on a deteriorating ice floe near a small hole. Two Polar Bears were feeding on the carcass when it was located, and numerous Belugas were seen a few kilometres away surfacing in holes in similar ice.

There are few reports describing interactions of Polar Bears and Belugas in the eastern Canadian Arctic. Degerbøl and Freuchen (1935) reported that bears were known to attack Belugas entrapped in ice in Baffin Bay. Freeman (1973) provided an interesting description of an event that occurred in March 1970 near the southeastern tip of Ellesmere Island. Local hunters reported that a medium-sized female Polar Bear had caught and removed three Belugas (one subadult, one adult female, and one adult of unknown sex) from a small open water area alongside a partially grounded iceberg. When Freeman visited the site some days later at least two other bears had been in the area, and two of the Beluga carcasses had disappeared, apparently having fallen into the water. Heyland and Hay (1976) examined a stranded juvenile Beluga in Cunningham Inlet, Somerset Island, that had deep, healed, parallel scars on the posterior

portion of the body that they thought were probably inflicted by a Polar Bear. They also noted that Polar Bears had once attacked captive Belugas being held in a tank at Churchill, Manitoba. Smith (1985), also working in Cunningham Inlet, reported nine sightings of Belugas with wounds that were ascribed to Polar Bears.

We are aware of only two published records of Polar Bear predation on Belugas in Eurasian waters, both from the vicinity of Novaya Zemlya. Tomilin (1957) stated that hunters there once found a group of 34 Belugas trapped near shore by ice. Three whales that had apparently been killed by bears were on the ice. Kleinenberg et al. (1964: p. 370) described an incident that occurred in 1940 as follows: "They saw that the bear was lying at the end of an ice floe with outstretched paws, and that the water in the hole was billowing with agitated Belukhas. As soon as a Belukha came to the surface near the bear, it received a crushing blow on the head, and the Belukha, weighing several hundred kilograms, was dragged on the ice. Thirteen Belukhas lay near the bear, but he did not cease killing."

These observations confirm that Polar Bears are capable of capturing and killing Belugas. Bear predation may occur in three basic environmental settings. The first is in situations where whales are entrapped in ice, which have been termed *savssats*¹. Such entrapments may be of long duration — for example when whales fail to move to favorable areas prior to extensive freeze-up in the fall (Hill 1967²; Freeman 1968), or of short duration when the movement of whales is temporarily restricted due to ice conditions. The other two settings involve free-ranging Belugas moving through narrow lead systems (e.g. our observation from off Cape Lisburne) or surfacing in holes in deteriorating ice sheets (Mitchell and Reeves 1981). These settings are similar in that the whales' access to air is restricted to small areas of open water where bears can hunt more effectively.

Polar Bears and Belugas may also interact in shallow, ice-free areas, where many whales spend the summer. Smith (1985) made detailed observations in one such area (Cunningham Inlet), and considered that although opportunities for

predation do occur, bears are rarely successful in catching whales and Belugas therefore do not make up a significant part of their summer diet.

Predation at entrapments appears to be the most widespread and common type. However, Brodie (1982) observed that the travel patterns and establishment of settlements of Canadian Inuit have evolved such that they take advantage of locations where whales may become entrapped. This creates a bias in that reports of entrapment are more common near inhabited and travelled areas. Also, *savssat* are reportedly easy to detect due to condensing vapors from the open water and breathing of the animals (Porsild 1918), and the noise whales make when surfacing (Vibe 1950). The success of Polar Bears hunting entrapped Belugas is virtually assured, and large numbers of whales may sometimes be killed.

Predation that occurs at leads or holes in deteriorating ice may be much less easily observed for several reasons. An event is more likely to involve a single bear and a single whale, and evidence of the kill may be obscured by moving ice or drifting snow. Also, predation may occur far from villages or travel routes on the ice and will go undetected unless the kill site is seen from an aircraft at low altitude. It is likely that hunting success of bears attempting to catch free-ranging Belugas in the ice is relatively low overall. The probability of successful capture will vary with ice conditions and the abundance of whales and bears in specific areas. Belugas that migrate through the lead system off western Alaska on their way to the eastern Beaufort Sea number at least 11 500 (Davis and Evans 1982³). Their migratory path passes through areas where we have regularly observed large numbers of Polar Bears. In our opinion, successful predation by bears on Belugas in the northern Bering and Chukchi seas probably occurs annually during the spring migration, simply because of the numerous opportunities for such interactions. In 1984, warm temperatures during March allowed the northward migration to begin as usual. Cold temperatures during April impeded the migration, causing some temporary entrapments, and also resulted in large aggregations of whales which passed Cape Lisburne in pulses when the leads were open. These conditions

¹Porsild (1918) described ice entrapment of marine mammals and introduced the anglicized Greenland Inuit term *savssats* (pronounced s'sets) into the scientific literature. According to Schultz-Lorentzen (1927) *savssat* is plural and refers to "whales or seals locked in a hole in the ice." The singular *savssaq* refers to one entrapped animal. In Alaska the equivalent words used by Inuit living in the area from Bering Strait to Point Hope are *sapraq* (singular) and *saprat* (plural).

²R. M. Hill. 1967. Observations on beluga whales trapped by ice in Eskimo Lakes winter 1966/67. Inuvik Research Laboratory Report, Inuvik, N.W.T.

³Davis, R. A., and C. R. Evans. 1982. Offshore distribution and numbers of white whales in the eastern Beaufort Sea and Amundsen Gulf, summer 1981. Report by LGL Limited, Toronto, Ontario, for SOHIO Alaska Petroleum Co. Anchorage, Alaska, and Dome Petroleum Limited, Calgary, Alberta. 78 pp.

may have enhanced the success of Polar Bears hunting Belugas.

Without further quantification, it is not possible to fully assess the significance of bear predation on populations of Belugas. Predation at leads and holes may involve mostly subadult whales, and is probably infrequent and of minimal significance. At entrapments, on the other hand, bears may kill many animals, both subadults and adults. In situations where whales would have perished due to prolonged entrapment in severe ice conditions during winter, predation would not increase the level of mortality but only change the cause. In situations where whales would have escaped from temporary entrapment, mortality due to predation would be additive. Since people hunt *savssat* there is little information on natural survival (Mitchell and Reeves 1981). It is, however, inappropriate to assume that all such confinements are fatal, as there is evidence that even after long periods of entrapment whales may survive and eventually escape to more favorable areas (Vibe 1950; Freeman 1968). Based on the photographs we examined, whales entrapped in the northern Bering Sea in 1984 would have escaped when nearby leads opened.

A final consideration is the possible importance of Belugas in the diet of Polar Bears. The prey of Polar Bears in the Canadian Arctic is primarily the Ringed Seal (*Phoca hispida*) and, secondarily, the Bearded Seal (*Erignathus barbatus*) (Stirling and Archibald 1977; Smith 1980). There have been no comprehensive studies of the diet of Polar Bears in Alaska. During our operations at Cape Lisburne in April-May we examined seven Polar Bear kill sites. In addition to the Beluga already described, those included two Ringed Seals, three Bearded Seals, and a group of five eider ducks (*Somateria* sp.). Best (1977) estimated that a Ringed Seal weighing 27.8 kg could supply the energy requirements of a 229 kg Polar Bear for 6.4 days. Assuming that the composition of the animals is similar, an average Beluga, which may weigh 600 kg, could provide the equivalent of 140 days of nourishment. Our observations, and those of others, indicate that when many Belugas are killed they are only partially eaten, while when only one whale is caught it may be entirely consumed. While the potential importance of Belugas in the diet of Polar Bears is clearly large, due to the difficulty of hunting free-ranging whales and the sporadic nature of *savssat*, this importance is probably rarely realized. It is possible, however, that the hunting strategy of Polar Bears in some areas may take advantage of places favorable for capturing Belugas. There are also several records of Narwhals (*Monodon monoceros*) found dead on the ice, presumably due to predation by

Polar Bears (Mitchell and Reeves 1981). Both Belugas and Narwhals should be considered as components of the diet of Polar Bears, with their importance, relative to other prey species, depending on environmental conditions and patterns of distribution and abundance.

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Literature Cited

- Best, R. C. 1977. Ecological aspects of polar bear nutrition. Pages 203-211 in *Proceedings of the 1975 Predator Symposium*. Edited by R. L. Phillips and C. Jonkel. University of Montana, Missoula.
- Brodie, P. F. 1982. The beluga (*Delphinapterus leucas*); growth at age based on a captive specimen and a discussion of factors affecting natural mortality estimates. Report of the International Whaling Commission 32: 445-447.
- Degerbøl M., and P. Freuchen. 1935. Mammals. Report of the Fifth Thule Expedition 1921-24. The Danish Expedition to Arctic North America in charge of Knud Rasmussen, Ph.D. Volume 2, numbers 4-5. 278 pp.
- Freeman, M. M. R. 1968. Winter observations on Beluga (*Delphinapterus leucas*) in Jones Sound, N.W.T. Canadian Field-Naturalist 82: 276-286.
- Freeman, M. M. R. 1973. Polar bear predation on beluga in the Canadian Arctic. Arctic 26: 163.
- Heyland, J. D., and K. Hay. 1976. An attack by a polar bear on a juvenile beluga. Arctic 29: 56-57.
- Kleinenberg, S. E., A. V. Yablokov, B. M. Belkovich, and M. N. Taresevich. 1964. Beluga (*Delphinapterus leucas*): Investigation of the species. Izdatel'stvo Nauka, Moscow. [Translated from the Russian by Israel Program for Scientific Translations, 1969. Available from National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22151].
- Mitchell, E., and R. R. Reeves. 1981. Catch history and cumulative catch estimates of initial population size of cetaceans in the eastern Canadian arctic. Report of the International Whaling Commission 31: 645-682.

- Porsild, M. P.** 1918. On "savssats": a crowding of arctic animals at holes in the sea ice. *Geographical Review* 6: 215-228.
- Schultz-Lorentzen, C. W.** 1927. Dictionary of the West Greenland and Eskimo Language. *Meddelelser om Grønland* 69: 1-303.
- Smith, T. G.** 1980. Polar bear predation of ringed and bearded seals in the land-fast sea ice habitat. *Canadian Journal of Zoology* 58: 2201-2209.
- Smith, T. G.** 1985. Polar Bears, *Ursus maritimus*, as predators of Belugas, *Delphinapterus leucas*. *Canadian Field-Naturalist* 99: 71-75.
- Stirling, I., and W. R. Archibald.** 1977. Aspects of predation of seals by polar bears. *Journal of the Fisheries Research Board of Canada* 34: 1126-1129.
- Tomilin, A. G.** 1957. Cetacea. Volume 9. *In: Mammals of the USSR and adjacent countries. Edited by V. G. Heptner.* Izdatel'stvo Akademii Nauk SSSR, Moscow. [Translated from the Russian by Israel Program for Scientific Translations, 1967. Available from National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22151].
- Vibe, C.** 1950. The marine mammals and marine fauna of the Thule District (northwest Greenland) with observations on ice conditions in 1939-41. *Meddelelser om Grønland* 150(6): 1-115.

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Evaluation of Indices of Gray Wolf, *Canis lupus*, Density in Hardwood-Conifer Forests of Southwestern Quebec

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Crête, Michel, and François Messier. 1987. Evaluation of indices of Gray Wolf, *Canis lupus*, density in hardwood-conifer forests of southwestern Quebec. *Canadian Field-Naturalist* 101(2): 147–152.

By radio-tracking 54 animals belonging to 14 packs, Gray Wolf density was estimated at 0.6–1.5 animals per 100 km² in two areas of southwestern Quebec with high and low prey density over a four-year period. These density estimates were related to five indices through regression analysis: wolves observed by moose hunters (WO), wolf howling heard by moose hunters (WH), percentage of moose hunters observing wolf scats (%S) or wolf tracks (%T), and number of scats dropped weekly by wolves on forest roads (WS). Predictive values of the regressions were somewhat limited because of the imprecision of parameters. Two other indices, aerial counts of wolf tracks in the snow and number of elicited wolf howling responses, were tested and judged unsatisfactory for management needs. The use of WH, and %S and %T, derived from hunter interviews, is recommended when wolf density cannot be calculated from radio-tracking because of lower variance and lower cost of collection as compared to the two other indices (WO and WS).

Grâce au radio-repérage de 54 loups appartenant à 14 meutes, la densité fut estimée, durant une période de 4 ans, à 0.6–1.5 individus par 100 km², pour deux endroits contigus du sud-ouest du Québec contenant peu et beaucoup de proies. L'analyse de régression a indiqué que les densités estimées étaient reliées à 5 indices: le nombre de loups observés par les chasseurs d'originaux (WO), l'audition de hurlements de loups par les chasseurs (WH), le pourcentage des chasseurs qui observèrent des fumées (%S) ou des pistes de loups (%T), et les fumées de loups dénombrées hebdomadairement sur les routes forestières. La valeur prédictive des régressions était toutefois limitée à cause de la précision des paramètres. Deux autres indices furent expérimentés et jugés inadéquats pour des fins de gestion: les décomptes, en avion, de pistes de loups dans la neige et le taux de réponse à des hurlements enregistrés. L'utilisation des indices WH, et %S et %T, tirés d'interviews de chasseurs, est recommandée quand la densité de loup ne peut être déterminée par radio-repérage, à cause de la variance moindre de ces indices et de leur coûts inférieurs d'obtention.

Key Words: Gray Wolf, *Canis lupus*, density, indices, Québec, survey.

Proper management of the Gray Wolf, *Canis lupus*, requires periodic assessment of population status. This view is particularly relevant in North America where predation by wolves can be an important mortality factor for ungulate prey (Murie 1944; Mech 1966; Peterson 1977; Keith 1983; Bergerud 1983; Gasaway et al. 1983; Messier and Crête 1985), even though there is still controversy regarding the level of wolf density most desirable for an integrated predator-ungulate management program (Gasaway et al. 1983).

Low wolf density combined with elusive behaviour makes most methods developed to estimate population size of large mammals (aerial inventory, line transects, and mark-recapture) unsuitable for wolves inhabiting vast areas of forested habitats. Mech (1974) proposed the use of radio-marked animals to determine pack size, territory size, and the area between territories in order to calculate wolf density. Although Mech's technique provides a total count, it is expensive and imposes severe restrictions on the sample area. For these reasons, biologists must

generally resort to some index of relative abundance when sampling areas covering many thousands of square kilometres.

In Ontario, intensive winter aerial surveys of wolf tracks and summer ground surveys of howling responses yielded similar estimates of pack numbers (Theberge and Strickland 1978). Harrington and Mech (1982) suggested monitoring wolf abundance by sampling howling responses. In this paper we assess the merits of seven indices of wolf abundance, measured within areas of known wolf density following intensive radio-tracking efforts, with respect to wolf management over large areas.

Study Areas and Methods

Wolf density was monitored in two contiguous, hardwood-conifer forest areas in southwestern Quebec (47°N, 77°W; Figure 1) from June 1980 to February 1984. The first area (3000 km²) covered a zone of high prey density (HP) in La Vérendrye reserve, and the second (3400 km²) was a zone of low prey density (LP). Moose, *Alces alces*, the major prey

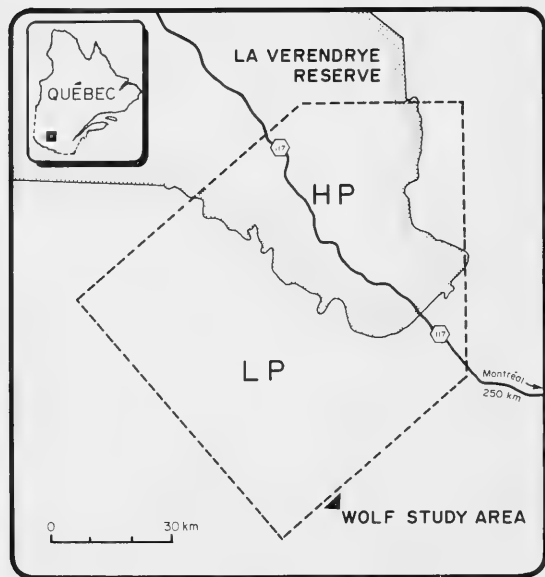


FIGURE 1. Location of the study areas HP (high prey density) and LP (low prey density) in southwestern Québec.

species of the wolf, were at a stable density of 0.37 animal/km² in HP, and declined during the study from about 0.25 to 0.21 animal/km² in LP (Messier and Crête 1984). Beaver, *Castor canadensis*, density was estimated at 3.5 colonies/10 km² in HP, and at 1 colony/10 km² in LP (unpublished). Wolves were radio-marked in both study areas and tracked intensively by aircraft to determine the annual January density (see Messier 1985a for details). The density estimates include pack members and temporarily solitary individuals but exclude lone wolves (about 5% of the population).

Indices of wolf density were derived from four sources: questionnaires to hunters, scat counts on forest roads, wolf howling responses, and aerial track counts. Questionnaires were addressed to moose hunters only. Hunters were met at compulsory check stations from 15 September to 24 October for four years (1981–1984). Hunters changed every year in HP because of controlled hunts in game reserves (Bouchard and Moisan 1974), but the clientele was more stable in LP. One person of each party ($n = 733$) was asked: 1) how many wolves did you personally see during your hunting trip? 2) on how many days (nights) did you personally hear wolves howling? 3) did you see any wolf scats? and 4) did you see any wolf tracks? In addition, the area hunted and the number of hunting-days were recorded. Most hunters were not aware of the questionnaire before their hunting trip.

From these results, we computed four wolf indices: the number of wolves observed/100 hunting-days (WO), the number of days (nights) with wolf howling/100 hunting-days (WH), the percentage of hunting trips with wolf scat observations (%S), and the percentage of hunting trips with wolf track observations (%T).

Weekly counts of wolf scats on forest roads were initiated in early July and repeated 10, 8, 8, and 6 times, respectively, for the summers 1980–1983. Before the 1980 counts, we recorded within each area all forest roads for which vehicle traffic was sufficiently low to ensure that most scats remained noticeable for a one-week period. Suitable road segments had an average length of $6.9 \pm$ (SD) 3.0 km. We randomly selected road segments to form a 48-km circuit within each study site. Counts were made by two observers in a team, patrolling on motorcycles at a maximum speed of 20 km/h. All scats were removed the week preceding the first count and collected thereafter. For each study site, the annual number of scats/100 km per week was calculated (WS).

Testing of summer howling responses was exploratory; responses were elicited according to the technique described by Harrington and Mech (1982) for a sampling census. Forest roads were randomly selected and we spaced 20 stations at 3-km intervals along these selected roads. Howling sessions were limited to July and August 1983, during nights with calm air. The sequence, number, and type of howls played on a tape recorder at each station were consistent with the recommendations of Harrington and Mech (1982). At each study site, censuses were repeated on three nights spaced at two-week intervals.

We conducted aerial track counts on seven occasions from January to March 1981 and 1982; this testing was also cursory. A flight path of 130 km per study area, composed of north-south transects at 5-km intervals, was surveyed. The length of each transect varied according to the contour of study sites. Within one day, we patrolled transects in both study sites aboard a DeHavilland DHC-2 Beaver aircraft (speed \approx 165 km/h; altitude above ground \approx 120 m). Two experienced observers, sitting on opposite sides in the back of the aircraft, reported wolf tracks they saw to a navigator in the front.

To test the sensitivity of each index to changing wolf abundance, wolf indices were regressed on the January wolf densities as determined by radio-tracking. We used the same-year density estimates for WO, WH, %S, and %T (i.e. indices derived from interviews), and the following January estimate for WS because scat counts began in summer 1980 and the first estimate of wolf density was obtained in January 1981. Intuitively, since these indices must

have a value of zero when wolf density is nil, we forced the regression to pass through the origin. Only one degree of freedom is lost in such analyses (Neter and Wasserman 1974: 156–159). Residuals were visually examined to verify the suitability of the regression models.

Variances of WO and WH were approximated by the procedure described by Cochran (1977: 64–68) for the estimation of proportions in cluster sampling. Here, a cluster is defined as a hunting excursion for which one obtains information on the number of wolves seen (or the number of days with howling) and the duration of the trip. With our data, we could obtain variance estimates of WO and WH in 1983 only because the occurrence (not the number) of wolf sighting or hearing was noted before. Indices %S and %T follow a binomial distribution and their variances were estimated by pq/n . We evaluated the variances of WS from the original weekly counts of scats along the 48-km circuits. Finally, we computed the sample size required to estimate each index within a given margin of error and confidence level from the procedure presented by Cochran (1977: 75–78).

Results

Wolf Density

Fifty-four wolves, members of 14 packs, were radio-tracked from 1980 to 1984. Year-specific wolf density, estimated from the technique of Mech (1974), ranged from 1.2 to 1.5 animals/100 km² in the HP area and from 0.6 to 1.0 animal/100 km² in the LP area (Messier 1985a). The number of packs considered per density estimate varied from three to eight (Table 1).

Indices of Wolf Density

Indices WO, WH, %S, %T, and WS were related to wolf density (Table 2). The slope of each regression equation was clearly different from zero ($P < 0.01$). The precision of the five regression models at 1.0 wolf/100 km² was variable (Table 2); the model with WH had the widest confidence interval, while the regression with WS, computed with 8 data points instead of 7, showed the best precision. However, the predictive ability of regression equations was relatively weak, particularly because of the limited sample sizes.

Often, biologists are interested in long-term trends in wolf density within an area. In such situations, indices with low variance should be favored in order to detect changes taking place over a number of years. The variance of WO is inherently large because wolf sightings rarely happen. Consequently, a large number of interviews (> 1500) would be needed to assess this index with a 20% confidence interval (Table 3). The variance of WH is smaller than the one of WO because wolves are heard howling more often than they are seen. Thus, fewer questionnaires (150–375) would be required to estimate this index (Table 3).

Indices %S and %T were less variable. About 100 hunter responses sufficed to evaluate %S and %T in the HP area in comparison to 200 and 600 in the LP area. Larger sample sizes are needed for precise estimates of small ratios (Cochran 1977: 54). Therefore, it is easier to evaluate trends of wolf abundance with the indices %S and %T when density is moderate to high (≥ 1.0 animal/100 km²).

Duration of hunting trips may influence the probability of noticing wolf scats or tracks (i.e. %S

TABLE 1. Estimates of Gray Wolf density in January in study sites HP and LP from 1981 to 1984 (Messier 1985a), and corresponding values of five indices of wolf abundance. No data = n.d.

Area - year	Wolves/ 100 km ²	No. packs included	Wolves observed per 100 hunting days	Wolves heard per 100 hunting days	% hunting trips with		Wolf scats/ 100 km week ^a
					scats seen	tracks seen	
HP - 81	1.2	3	3.5	7.4	48	61	4.2
HP - 82	1.3	5	3.2	12.1	41	61	4.7
HP - 83	1.5	4	5.0	3.6	28	37	6.3
HP - 84	1.5	3	3.1	9.4	38	73	8.0
LP - 81	0.6	5	1.9	2.1	9	32	2.9
LP - 82	1.0	5	0.9	4.5	11	25	7.8
LP - 83	0.8	8	0.3	1.1	11	14	2.1
LP - 84	0.9	8	n.d.	n.d.	n.d.	n.d.	6.2

^avalues obtained in summers 1980–83.

TABLE 2. Regression relationships, through the origin, between wolf density in January (WD) and five indices of wolf abundance (see Methods for abbreviations). The 90% confidence intervals (CI) of a predicted mean (\bar{y}_n) [1.0 wolf/100 km²] are presented in order to compare the precision of the five equations. Statistical procedure was extracted from Neter and Wasserman (1974: 156–159).

Regression equations ($y = b_1x_n$)	r^2	n	$s(b_1)$	P of zero slope ^a	CI ($\bar{y}_{1.0}$)
WD = 0.367 WO	0.87	7	0.057	0.01	1.0 ± 30%
WD = 0.155 WH	0.81	7	0.030	0.01	1.0 ± 37%
WD = 0.061 arcsin (%S)	0.87	7	0.0095	0.01	1.0 ± 30%
WD = 0.037 arcsin (%T)	0.89	7	0.0054	0.01	1.0 ± 28%
WD = 0.190 WS	0.90	8	0.022	0.01	1.0 ± 22%

$$^a t_{[n-1]} = b_1/s(b_1)$$

and %T). Overall mean trip duration varied little between our two areas during the study: $3.2 \pm$ (SD) 1.0 days and $4.1 \pm$ (SD) 2.7, respectively, in HP and LP. However, for a typical year with $n \approx 50$ and 300, respectively, in HP and LP, this difference was statistically significant ($P < 0.05$). To isolate possible effects, we selected a large set of data ($n = 224$) and ran a test of goodness of fit (χ^2) among eight classes of trip durations (1, 2, . . . , 8+ days). The analysis revealed that the number of days had no effect ($P > 0.10$) on indices %S and %T. This finding can be explained by the patchy distribution of wolves. If the moose hunting ground happens to be in an area of current (or recent) wolf activities, hunters quickly notice wolf sign. Alternately, if the hunting ground is located within an area temporarily devoid of wolves, hunters'

chances of seeing wolf sign are poor, regardless of trip length.

Variance of WS was relatively large, requiring about 70–80 sampling-weeks to assess this index with a 20% confidence interval (Table 3). Such a sampling effort is not feasible in most cases. It is possible that the variance of WS can be reduced by using circuits longer than 48 km. We consider that WS may be a reliable index of wolf abundance, but the technique requires a substantial amount of work. We were able to patrol 30–40 km of randomly selected road segments daily, or complete a three-days-per-week count over the two study sites (about 50 working-days for an entire season). We did not detect any significant change in the rate of scat deposition in HP and LP together from early July to mid August when pooling all four years (Friedman test; $N = 8$, $k = 6$, $P > 0.10$), nor when separating every year ($N = 2$, $k = 6$, $P > 0.15$) (Siegel 1956: 166–173). We encountered one difficulty during a scat count when a group of wolf pups temporarily moved near a road segment (i.e. a rendezvous site). For that particular road segment, scats were about 10 times more numerous (1 scat every 100 to 200 m) and they were smaller in size. We suggest eliminating such data, which occur rarely, so as to keep counts mainly for scats of adult wolves.

Wolf responses to our tape recordings were sporadic: we heard responses in only 4 of the 60 night-stations in the HP area, and no responses at the 60 night-stations in LP. No groups of pups were located during the six full nights howling was conducted. Traveling between selected roads, and between stations, was time consuming. From our experience, a set of 20 stations constitutes the maximum workload that one person can accomplish during a night (7–8 h). Assuming a rate of wolf response as in the HP area, the assessment of this index within a 20% confidence interval would require about 940 stations.

Track counts from aircraft along predetermined transects were highly variable: 4.1 tracks/100 km (SD = 3.0, $n = 7$) in HP area and 3.6 tracks/100 km

TABLE 3. The unweighted, 1981–84 average values of five wolf indices in study sites HP and LP, their variance, and the required sample size (n) to evaluate each index with a confidence interval (CI) of 20% ($\alpha = 0.10$). Variances of WO and WH were estimated in 1983 only; variances of the other indices were derived from the average year-specific variances to improve the estimation.

Area - index	Average index value	S^2 of the index	Required n^a (CI = 20%, $\alpha = 0.10$)
HP - WO	3.7	3.8	1880
HP - WH	8.1	1.4	142
HP - %S	38.7	23.7	106
HP - %T	58.0	24.0	49
HP - WS	2.7	7.8	72
LP - WO	1.0	0.26	1677
LP - WH	2.6	0.37	374
LP - %S	10.3	9.2	589
LP - %T	23.7	18.1	214
LP - WS	2.3	6.4	85

^a = the number of questionnaires for indices WO, WH, %S, and %T, or the number of sampling-weeks for index WS.

(SD = 2.5, $n = 7$) in LP area. In addition, the number of wolf tracks per crossing could not be assessed from the air with certainty. Of 26 tracks ground-checked, 16 belonged to Wolves, 6 to Red Foxes, *Vulpes vulpes*, 2 to Lynxes, *Lynx canadensis*, and 1 to a River Otter, *Lutra canadensis*. The observers, who were experienced, misinterpreted about 35% of the tracks. Under similar conditions, F. Goudreault (unpublished) evaluated the observers' error at 22% ($n = 46$) in central Quebec. Other major problems encountered were the difference in the degree of open areas between sites, the time elapsed from the last snowfall, the general condition of snow (which affected wolf movements), the quality of light in relation to the contrast of tracks over snow, and the obliteration of tracks by wind. For these reasons and the high cost of operation, we abandoned the technique.

Discussion

Regression analysis indicated that WO, WH, %S, %T, and WS were related to wolf density in southwestern Québec. The use of our regressions to predict density should be made with caution because of the imprecision of the parameters. Regressions may be valid for other comparable regions, but users should consider that some variables (hunting methods, road system, and type of substrate) may significantly affect the results. A second note of warning concerns the fact that the dependent variables in the regression analysis were associated with a sampling error. If the indices are assessed from sample sizes smaller than those we propose in Table 3, predicted results may be still more misleading.

Our results justify the use of WO, WH, %S, %T, and WS as indices of wolf density. In particular, they represent an acceptable means of monitoring wolf density over years within an area. We advocate the use of hunter interviews for financial reasons. In Québec, many hunting areas have controlled access. Gate personnel can routinely ensure that hunters complete the questionnaire after their excursion. We selected moose hunters in this study but we presume that other groups of hunters (or persons) could correctly answer the questionnaire if they were minimally acquainted with wolf sign and habits. The statistical correspondence between the different indices and wolf density suggests that most answers were not biased if asked immediately after the hunt. Therefore, it is not fundamentally unsound to rely on hunter reports for this kind of information.

Harrington and Mech (1982) proposed a wolf census method based on elicited howling. Their results indicate that if you know *a priori* where wolves are located, they often reply to nearby (0.2–1.0 km) simulated howls. However, a field validation of the

technique, using predetermined stations, was not provided. The reply rate in our study was extremely low (about 3%). To some extent, this low rate is not surprising, but poses statistical problems of precision when sampling. By assuming a radius of coverage of 1.5 km per station (after Harrington and Mech 1982), about 30 to 50 stations would be necessary to cover a single 300 to 500 km² wolf territory in moose habitat (Fuller and Keith 1980; Peterson et al. 1984; Messier 1985a), or 2 to 3 days of work. Also, we have evidence that pups often stay within areas not readily accessible by vehicle, thus reducing the chance to census them by howling stimulus. Considering these two difficulties, and others discussed by Harrington and Mech (1982), we are inclined not to recommend this technique. At best, the technique may provide an index of wolf abundance (Theberge and Strickland 1978) but it will, nonetheless, require a considerable amount of work and expense.

Indices have unavoidable limitations in predicting wolf abundance among areas because of the diversity in the habitat and in the methods used by hunters. However, we wish to propose some recommendations drawn from our experience concerning estimation of absolute wolf densities. In small areas (1000–2000 km²), wolf density is determined most reliably by radiomarking individual wolves from resident packs. Radio-tracking can be used to assess pack size and territory size, and thereby estimate wolf density (Mech 1974). Field work should be conducted mainly between November and February, a period when packs demonstrate a high degree of cohesion and mobility (Mech 1970; Peterson et al. 1984; Messier 1985a, b). Investigators should plan at least 40 to 50 telemetry flights to estimate territory size properly at that time of year.

A second method is the repetitive search for resident packs by following their tracks in snow from an aircraft. Mech (1966), Jordan et al. (1967), Peterson (1977), and Peterson and Page (1983) used this technique with success at Isle Royale, Michigan (544 km²). It should be noted that repetitive searches always provide a minimal count; in a mainland situation, one or several packs may be temporarily absent from an arbitrary census area because of extraterritorial excursions or territories that straddle census area boundaries (Van Ballenberghe 1983; Peterson et al. 1984; Messier 1985b).

For larger areas, Gasaway et al. (1983) evaluated wolf density in Alaska from aerial reconnaissance. This approach seems realistic in relatively open areas, as in Alaska, where wolves or tracks are highly visible. However, in forested habitats, we have serious reservations for several reasons: 1) the number of tracks per crossing cannot be determined without

prolonged ground tracking (not just a check); 2) tracks are frequently lost by an aerial observer which means that two sets of tracks may be related; 3) tracks are often misidentified; and 4) signs of some packs may be missed completely. Regarding the last point, Messier (1985a) presented evidence that a pack feeding on a moose carcass may remain within a restricted area of a few km² for the entire consumption time (2–15 days). Therefore, an aerial search along transects may fail to locate all packs if transects are not tightly spaced. These considerations indicate that estimates of wolf numbers based on cursory observations of wolf tracks or unmarked packs (e.g. Bergerud et al. 1983) should be interpreted with great caution. For large areas, we recommend sampling small areas for which absolute abundance can be assessed by radio-tracking or repetitive search for resident packs. It appears that there is no inexpensive way to evaluate the absolute wolf density over large forested areas. An alternative is to assess the trend of wolf abundance with the aid of validated indices.

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Literature Cited

- Bergerud, A. T.** 1983. The natural population control of Caribou. Pages 14–61 in *Symposium on the natural regulation of wildlife populations*. Edited by F. L. Bunnell, D. S. Eastman, and J. M. Peek. Forest, Wildlife, and Range Experiment Station, University of Idaho, Moscow, Idaho.
- Bergerud, A. T., W. Wyett, and B. Snider.** 1983. The role of wolf predation in limiting a moose population. *Journal of Wildlife Management* 47: 977–988.
- Bouchard, R., and G. Moisan.** 1974. Chasse contrôlée à l'original dans les parcs et réserves du Québec (1962–1972). *Le Naturaliste canadien* 101: 689–704.
- Cochran, W. G.** 1977. *Sampling techniques* (Third Edition). John Wiley and Sons, New York. 428 pp.
- Fuller, T. K., and L. B. Keith.** 1980. Wolf population dynamics and prey relationships in northeastern Alberta. *Journal of Wildlife Management* 44: 583–602.
- Gasaway, W. C., R. O. Stephenson, J. L. Davis, P. E. K. Shepherd, and O. E. Burris.** 1983. Interrelationships of wolves, prey, and man in interior Alaska. *Wildlife Monograph* 84. 50 pp.
- Harrington, F. H., and L. D. Mech.** 1982. An analysis of howling response parameters useful for wolf pack censusing. *Journal of Wildlife Management* 46: 686–693.
- Jordan, P. A., P. C. Shelton, and D. L. Allen.** 1967. Numbers, turnover, and social structure of the Isle Royale wolf population. *American Zoologist* 7(2): 233–252.
- Keith, L. B.** 1983. Population dynamics of Wolves. Pages 66–77 in *Wolves in Canada and Alaska, their status, biology and management*. Edited by L. N. Carbyn. Canadian Wildlife Service, Ottawa, Report Series 45.
- Mech, L. D.** 1966. The wolves of Isle Royale. U.S. National Park Service Fauna series Number 7. 210 pp.
- Mech, L. D.** 1970. *The wolf*. Natural History Press, Garden City. 384 pp.
- Mech, L. D.** 1974. Current techniques in the study of elusive wilderness carnivores. *Proceedings of the International Congress of Game Biology* 11: 315–322.
- Messier, F.** 1985a. Social organization, spatial distribution, and population density of wolves in relation to moose density. *Canadian Journal of Zoology* 63: 1068–1077.
- Messier, F.** 1985b. Solitary living and extraterritorial movements of wolves in relation to social status and prey abundance. *Canadian Journal of Zoology* 63: 239–245.
- Messier, F., and M. Crête.** 1984. Body condition and population regulation by food resources in moose. *Oecologia (Berlin)* 65: 44–50.
- Messier, F., and M. Crête.** 1985. Moose-wolf dynamics and the natural regulation of moose populations. *Oecologia (Berlin)* 65: 503–512.
- Murie, A.** 1944. The wolves of Mount McKinley. U.S. National Park Service Fauna series Number 5. 238 pp.
- Neter, J., and W. Wasserman.** 1974. *Applied linear statistical models*. Richard D. Irwin, Homewood, Illinois. 842 pp.
- Peterson, R. O., and R. E. Page.** 1983. Wolf-moose fluctuations at Isle Royale National Park, Michigan, USA. *Acta Zoologica Fennica* 174: 251–253.
- Peterson, R. O.** 1977. Wolf ecology and prey relationships on Isle Royale. National Park Service Scientific Monograph Series Number 11. 210 pp.
- Peterson, R. O., J. D. Woolington, and T. N. Bailey.** 1984. Wolves of the Kenai Peninsula, Alaska. *Wildlife Monograph* 88. 52 pp.
- Siegel, S.** 1956. *Nonparametric statistics for the behavioral sciences*. McGraw-Hill, Toronto. 312 pp.
- Theberge, J. B., and D. R. Strickland.** 1978. Changes in wolf numbers, Algonquin Park, Ontario. *Canadian Field-Naturalist* 92: 395–398.
- Van Ballenberghe, V.** 1983. Extraterritorial movements and dispersal of wolves in southcentral Alaska. *Journal of Mammalogy* 64: 168–171.

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Notes

An Observation of Renesting by a Ruddy Duck, *Oxyura jamaicensis*

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Tome, Michael W. 1987. An observation of renesting by a Ruddy Duck, *Oxyura jamaicensis*. Canadian Field-Naturalist 101(2): 153–154.

After I removed eggs from the nests of five marked, incubating Ruddy Ducks (*Oxyura jamaicensis*), one female renested. Its carcass contained 45.6 g of lipid, significantly less than in females incubating first nests (72.2 g). This may reflect endogenous lipid catabolized to supplement dietary intake during egg production. Protein content (86.1 g) was not significantly different from that of first-nest females (88.1 g).

Key Words: Ruddy Duck, *Oxyura jamaicensis*, renest, breeding biology, Manitoba.

Renesting, or the production of a second clutch of eggs after the loss of a first nest, has not been documented in the tribe Oxyurini, although Siegfried (1976) and Gray (1980) suggested that renesting occurs in the populations of Ruddy Ducks, *Oxyura jamaicensis*, that they studied. H. Hays (*in* Bellrose 1980) noted that a Ruddy Duck nested close to a nest that had been destroyed earlier in the breeding season and suggested that this might represent a renest. The female in that situation was not marked, however, and other explanations are possible.

The objective of this paper is to report on the results of a pilot study I conducted in 1979 to determine if female Ruddy Ducks could be induced to renest. The study could not be repeated on a larger scale during the 1980 or 1981 field seasons because wetland water levels on the study area were low, resulting in poor conditions for reproduction; consequently, few nests were produced by Ruddy Ducks (M. W. Tome, unpublished data).

Methods

I studied Ruddy Ducks in the prairie pothole region of southwestern Manitoba, approximately 16 km southeast of Minnedosa, 50°11'N, 99°42'W. I selected five females for the renesting experiment on the basis of stage of incubation (less than 10 days, estimated by candling; Weller 1956) and time of nest initiation (prior to 30 June). These criteria were selected to minimize the renesting interval (Sowls 1955) and to allow sufficient time for a possible renesting effort.

Females were captured using a modified Weller (1957) nest trap. To avoid trapping a female laying a

parasitic egg, I only captured females on nests that had been monitored for at least 7 days to ensure that they had not been parasitized by other females. Ruddy Ducks lay their eggs in the early morning (M. W. Tome, unpublished data); therefore, I only nest-trapped females in the afternoon and I palpated the abdomens of captured females to detect oviducal eggs, which would indicate a female parasitizing the incubating hen's nest. I individually marked birds for subsequent identification using bleached Ruddy Duck rectrices that were inserted with small pins and glue into the calami which remained when the bird's rectrices were cut off flush with the tail skin (Wright 1939).

After I captured and marked the females, I collected their eggs and destroyed their nests. At least 1 week after their nests were destroyed, I searched for renests in the vegetation of wetlands where I observed marked females during weekly surveys of the 15.6 km² study area. More casual surveys of the wetlands surrounding the study area were also conducted (1–2 per month). The renesting female I located was trapped on the nest (using the previously described criteria to avoid capturing a parasitic hen) and sacrificed with sodium pentathol. I candled the renest eggs to estimate the age of the embryos and calculated the renesting interval by backdating. These eggs were placed in an incubator and hatched to provide a more accurate estimate of the stage of incubation.

Lipid and protein content of the carcass were determined as described by Tome (1984). Where sample sizes permit, results are summarized using means \pm 1 SE.

Results

Of the five females marked, only one (#67) stayed on the pond where she originally nested; a second female (#48) moved to another wetland approximately 0.2 km west of her original nest site. I never observed the other three birds again.

I discovered the nest of female #67 on 12 June with 11 eggs that were all in the first day of incubation. On 21 June, I trapped and marked the female, which weighed 630 g. On 11 July, I recaptured female #67 on a second nest of 9 eggs that had all been incubated for 8 days. At that time she weighed 502 g. I estimated the renest interval to be 4 days. Analysis of this bird's carcass indicated that it contained 45.6 g of lipid and 86.1 g of protein.

Another possible renest was not verified. Female #48 was marked during the fifth day of incubation on 2 July. I subsequently observed her on 13 July and on three occasions saw her swimming into the same section of emergent vegetation. When the area was searched on 15 July, I located a nest containing six unincubated eggs. I was unable to trap or collect the female and she abandoned the nest.

Discussion

My study shows that Ruddy Ducks are capable of producing a second clutch of eggs. The renesting interval of 4 days that I measured seems extremely short, as Grau (personal communication in Gray 1980) estimated the time required for recrudescence of follicles to the point of ovulation in Ruddy Ducks to be 11 days. A female that loses a nest early in incubation, however, does not require such a long period for follicle development. Sows (1955) reported that the renesting interval of Mallards, *Anas platyrhynchos*, is 3 days for birds in the first few days of incubation and increases by 0.62 days for each subsequent day of incubation.

It is possible that female #67's second nest was intraspecifically parasitized by one or more females during the laying period; if so, the laying period would have been shorter and the renesting interval longer than calculated by backdating. Unfortunately, the ruptured follicles in the ovary of the renesting bird had regressed so that I could not ascertain the number of eggs laid.

Even though the renesting interval likely was somewhat more than 4 days, the renesting female produced a second clutch in a short period of time. The source of the nutrients necessary to produce this renest clutch remains of interest. Females in the early incubation stage (less than 12 days) of first nests weigh 594 ± 15 g and contain 72.2 ± 8.7 g lipid and 88.1 ± 2.0 g protein ($n=9$; Tome 1984). The weight of the renesting female (502 g) was much closer to

weights of late incubation (greater than 12 days) female Ruddy Ducks (509 ± 14 g; $n=8$; Tome 1984). The 45.6 g of lipid observed in the renesting female is significantly less ($t=3.053$; $P<0.05$) than lipid content of females incubating first nests; however, the protein content of 86.1 g did not differ ($P>0.05$) from that of females at a similar stage of incubation on first nests. Female Ruddy Ducks producing first clutches provide only 35% (31 g) of the lipid requirements of an eight-egg clutch from stored lipids (Tome 1984). The decrease in body weight of 128 g between the first and second captures of the renesting hen and the difference in lipid content between the renesting hen and other early incubating females (26.6 g) may reflect a similar contribution of endogenous nutrient for egg formation in a second clutch. This would indicate that renesting female Ruddy Ducks are also primarily dependent upon exogenous energy sources during laying for meeting the nutrient requirements of egg formation.

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Literature Cited

- Bellrose, F. C. 1980. Ducks, geese, and swans of North America. Third edition. Stackpole Books, Harrisburg, Pennsylvania.
- Gray, B. J. 1980. Reproduction, energetics, and social structure of the Ruddy Duck. Ph.D. thesis, University of California, Davis, California. 158 pp.
- Siegfried, W. R. 1976. Breeding biology and parasitism in the Ruddy Duck. *Wilson Bulletin* 88(4): 566-574.
- Sows, L. K. 1955. Prairie ducks: a study of their behavior, ecology, and management. Stackpole Books, Harrisburg, Pennsylvania.
- Tome, M. W. 1984. Changes in nutrient reserves and organ size of female Ruddy Ducks breeding in Manitoba. *Auk* 101(4): 830-837.
- Weller, M. W. 1956. A simple field candler for waterfowl eggs. *Journal of Wildlife Management* 20(2): 111-113.
- Weller, M. W. 1957. An automatic nest trap for waterfowl. *Journal of Wildlife Management* 21(4): 456-458.
- Wright, E. G. 1939. Marking birds by imping feathers. *Journal of Wildlife Management* 3(3): 238-239.

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Spruce Grouse, *Canachites canadensis*, Feeds on Needles of Red Pine, *Pinus resinosa*

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Davis, William E., Jr. 1987. Spruce Grouse, *Canachites canadensis*, feeds on needles of Red Pine, *Pinus resinosa*. Canadian Field-Naturalist 101(2): 155.

A male Spruce Grouse, *Canachites canadensis*, was observed feeding on the needles of Red Pine, *Pinus resinosa*. Spruce Grouse seldom feed on long-neededled pines and no previous record for Red Pine was found. Intensive browsing on pine needles in August is unusual, since Spruce Grouse usually shift to a conifer needle diet only in fall or early winter.

Key Words: Spruce Grouse, *Canachites canadensis*, Red Pine, *Pinus resinosa*, forage, browse, Ontario.

In this note I report on a Spruce Grouse, *Canachites canadensis*, foraging intensively on the long needles of a Red Pine, *Pinus resinosa*, on 9 August 1985.

I observed a male Spruce Grouse near the Spruce Bog Walk in Algonquin Provincial Park, Ontario, (45°36'N, 78°21'W) at 1515 h. He was perched about halfway up a 10-m Red Pine at the edge of a 30-m clearing with scattered spruce, *Picea* sp., trees and a ground cover of ferns. The bird was very tame, and within five minutes began to forage on the pine needles. The bird fed on a single spray, clipping off one-cm snips of individual 10-cm long needles (\bar{x} = 9.9 cm for three sprays, n = 62 needles), until it had eaten four or five halfway to the base. Then he walked to another bough and repeated the foraging pattern. I watched it forage for 25 minutes, and when I left he was still feeding.

Spruce Grouse commonly feed extensively on pine and spruce needles during winter, particularly after snow makes ground forage unavailable (Keppie 1977). The use of pine needles is low in summer when a variety of other foods are available (Pendergast and Boag 1970).

Spruce Grouse largely depend on short-neededled pines in many geographic regions. Lodgepole Pine, *P. contorta*, is the dominant winter food of Spruce Grouse in north-central Washington State (Zwickel et al. 1974) and central Alberta (Pendergast and Boag 1970), whereas Jack Pine, *P. banksiana*, is a winter staple in Michigan (Robinson 1980) and central Ontario (Crichton 1963). The preference for short-neededled pines (Jack and Lodgepole) is well known (Ammann 1963; Robinson 1980), and the only references I found to the use of long-neededled pines were a personal communication by Margaret Herman (Robinson 1980) relating the common use of

Ponderosa Pine, *P. ponderosa*, needles by Spruce Grouse in Montana, and the presence of these needles in the crop of one bird in Washington State (Zwickel et al. 1974). The protein level of Red Pine does not differ significantly from that of Jack Pine or Lodgepole Pine (Gurchinoff and Robinson 1972). However, Spruce Grouse make only marginal use of habitats where Red Pines are abundant (Pietz and Tester 1974) and this may explain why this tree has not previously been reported as a food item.

Literature Cited

- Ammann, G. A. 1963. Status of Spruce Grouse in Michigan. Journal of Wildlife Management 27: 591-593.
- Crichton, V. 1963. Autumn and winter foods of the Spruce Grouse in Central Ontario. Journal of Wildlife Management 27: 597.
- Gurchinoff, S., and W. L. Robinson. 1972. Chemical characteristics of jackpine needles selected by feeding Spruce Grouse. Journal of Wildlife Management 36: 80-87.
- Keppie, D. M. 1977. Snow cover and the use of trees by Spruce Grouse in autumn. Condor 79: 382-384.
- Pendergast, B. A., and D. A. Boag. 1970. Seasonal changes in diet of Spruce Grouse in central Alberta. Journal of Wildlife Management 34: 605-611.
- Pietz, P. J., and J. R. Tester. 1982. Habitat selection by sympatric Spruce Grouse *Canachites canadensis* and Ruffed Grouse *Bonasa umbellus* in north central Minnesota USA. Journal of Wildlife Management 46: 391-403.
- Robinson, W. L. 1980. Fool hen. University of Wisconsin Press, Madison.
- Zwickel, F. C., D. A. Boag, and J. H. Brigham. 1974. The autumn diet of Spruce Grouse: a regional comparison. Condor 76: 212-214.

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News and Comment

Editor's Report for Volume 100 (1986)

There were 137 manuscripts submitted to *The Canadian Field-Naturalist* in 1986, compared to 136 in 1985. Processing of manuscripts was slow throughout the year but will be complete early in 1987. Thanks are due to all authors who maintained patience in face of these delays. Volume 100 (1) was mailed 30 July 1986, (2) 3 October 1986, (3) 31 December 1985, (4) 27 February 1987. It contained 618 pages and was largest in the history of the journal; the previous high was 586 pages in 1985.

Included in 100(3) was the first group of abridged Status Reports for the Subcommittee on Plants of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and the efforts of subcommittee chairman Erich Haber in editing them are particularly appreciated. These continued the partial coverage of approved COSEWIC Status Reports begun in 1984 and continued in 1985 with the publication of those available for Fish and Marine Mammals. The seventh contribution to *The Biological Flora of Canada* series appeared in 100(1). Volume 100 was commemorated by historical overviews of the journal history by FRC in 100(1): 140-142 and by D. F. Brunton in 100(3): 423-426. A tribute by W. J. Cody to the scientific contribution made by Research Branch, Agriculture Canada, which celebrated its centennial in 1986, appeared in 100(3): 418-422. The revised Constitution and By-laws of the Ottawa Field-Naturalists' Club were published in 100(3): 435-440 and two tributes to past members appeared: V. Humphreys (100(2): 278-279) and B. Boivin (100(2): 280-288). The number of research and observation articles and notes is given in Table 1, the number of book reviews and new titles by topic in Table 2, and the number of published pages by section in Table 3.

A. J. Erskine (birds); C. G. Van Zyll de Jong and W. O. Pruitt, Jr. (mammals), C. Jonkel (predator-prey relationships), D. E. McAllister (fishes), S. M. Smith (insects), E. L. Bousfield (invertebrates), and C. D. Bird (plants) all continued their active roles as associate editors concerned with papers in their respective fields. Their efforts were supplemented and aided by outside reviewers who have contributed, largely anonymously, to the critical evaluation of manuscripts that is vital to the standards of any scientific journal. The following are gratefully

acknowledged for one or more individual reviews during 1986: P. L. Achuff, G. H. Adler, G. W. Argus, W. B. Ballard, P. W. Ball, J. Baskin, I. L. Bayley, R. J. Beamish, M. Berrill, J. R. Bider, D. M. Bird, J. S. Bleakney, D. A. Boag, D. M. Britton, W. K. Brown, A. B. Bubenike, C. H. Buckner, F. Bunnell, R. R. Campbell, R. W. Campbell, L. N. Carbyn, P. M. Catling, C. S. Churcher, B. W. Coad, W. J. Cody, F. Cooke, R. D. Crawford, E. J. Crossman, S. L. Cumbaa, J. A. Curatolo, P. Currie, H. E. Danks, W. R. Darby, M. E. Floyd, L. H. Frederickson, B. Freedman, V. Geist, F. F. Gilbert, W. E. Godfrey, J. Gilhen, J. Ginns, R. H. Green, E. Haber, N. Hagen, F. Hamerstrom, R. M. Hansen, V. L. Harms, J. Hemming, S. M. Herrero, J. I. Hodges,

TABLE 1. Number of research and observation manuscripts published in *The Canadian Field-Naturalist* volume 100 (1986) by major field of study.

Subject	Article	Notes	Total
Mammals	21	16	37
Birds	10	17	27
Amphibians and Reptiles	3	3	6
Fish	4	6	10
Invertebrates	1	4	5
Plants	12*	7	19*
Paleontology	1	0	1
Total	52†	53	105

*includes one article in *The Biological Flora of Canada* series.

†in addition there were four COSEWIC articles (one subcommittee report and three status reports on plants).

TABLE 2. Number of book reviews and new titles published in the Book Review section of volume 100 by topic.

	Reviews	New Titles
Zoology	42	151
Botany	21	83
Environment	16	154
Miscellaneous	7	39
Young Naturalists	—	60
Total	86	487

TABLE 3. Number of pages published in *The Canadian Field-Naturalist* volume 100 (1986) by section (number of manuscripts in parentheses).

Issue number:	-1-	-2-	-3-	-4-	Total
Articles	88 (13)	86 (14)	56 (10)	91 (14)	321 (52)
Biological Flora of Canada	16 (1)	— —	— —	— —	16 (1)
Notes	35 (16)	21 (13)	27 (14)	20 (10)	103 (53)
News and Comment	3 (1)	4 (7)	2 (2)	4 (3)	13 (13)
COSEWIC	— —	— —	18 (4)	— —	18 (4)
Tributes	— —	11 (2)	— —	— —	11 (2)
Other	— —	— —	9 (2)	— —	9 (2)
OFNC Annual Meeting	— —	— —	8 (1)	— —	8 (1)
Constitution & By-laws	— —	— —	6 (2)	— —	6 (2)
Book Reviews	23 (24)	26 (26)	22 (21)	20 (15)	91 (86)
Index	— —	— —	— —	21 (1)	21 (1)
Advice to Contributors	1 (1)	— —	— —	— —	1 (1)*
	166 —	148 —	148 —	156 —	618 —

*in addition issues 2, 3, and 4 contained a shortened version on the bottom of the final page included in the count for other categories.

M. G. Hornocker, J. R. Hunter, R. D. James, A. Keast, L. B. Keith, D. Keppie, G. L. Kirkland, D. Klein, R. W. Knapton, K. Koopman, J. Kuijt, E. Kuyt, A. K. Lamsa, D. J. Larson, D. Laubitz, M. R. Lein, J. Lien, H. G. Lumsden, G. M. Lynch, S. D. MacDonald, D. Malloch, R. McNeil, L. D. Mech, A. L. A. Middleton, J. S. Millar, J. K. Morton, N. Mrosovsky, B. Munro, M. T. Myres, D. Nagorsen, R. W. Nero, L. Oliphant, R. B. Owen, A. E. Peden, M. R. Peterson, R. L. Peterson, R. O. Peterson, J. Prescott, G. Proulx, T. E. Reimchen, D. Renouf, H. Reynolds, D. Rimmer, D. A. Russell, L. S. Russell, J. P. Ryder, F. W. Schueler, F. Scott, S. G. Sealy, D. E. Sergeant, M. Shoesmith, F. F. Snelson, Jr., K. W. Stewart, D. Thomas, W. T. Threlfall, D. W. Uresk, N. A. M. Verbeek, P. J. Weatherhead, D. A. Welsch, D. V. Weseloh, N. D. Yan, P. M. Youngman, and F. C. Zwickel.

George LaRoi continued as Coordinator of *The Biological Flora of Canada* series, E. Wilson Eedy as Book Review Editor, and W. J. (Bill) Cody as Business Manager. W. Harvey Beck again compiled the volume Index under the strain of the last issue already being late when it reached him in page proof.

Recording of manuscripts, acknowledgment of their receipt, mailings and acknowledgments to reviewers and all record keeping was again processed by Barbara Stewart until late in the year when she

moved on to more rewarding employment. Her contribution will be greatly missed. Proof-reading of galley proofs has continued to be carried out thoroughly and quickly by Louis L'Arrivée. Thérèse Giroux has typed correspondence and R. Michael Rankin has provided liaison with the printer. Elizabeth Morton made a major contribution by serving as general editorial assistant throughout the year, editing manuscripts before and after revision, marking them for typesetting, collating galley corrections, checking page proofs and sharing her knowledge gained through completing an MA in English. She also filled in for Barbara at the end of the year to complete a thorough grounding in all stages of processing manuscripts. M. O. M. Printers continued to set and print the journal, and as usual we are all indebted to Emil Holst and Eddie Finnigan. My thanks are also due the National Museum of Natural Sciences for continuing to allow me partial space and time for editing on the principle that such support contributes to its mandate to disseminate knowledge, to R. E. Bedford and the publications committee for their continued faith, to Dan Brunton for his contributions, and to Joyce for generally maintaining my perspective.

FRANCIS R. COOK
Editor

Book Review Editor's Report for Volume 100 (1986)

Every year there is an increasing number of new books published on topics of interest to field naturalists. In 1986 (Volume 100) the Canadian Field-Naturalist published a new record number of 487 **New Titles**. The 76 books received from publishers, to be reviewed in our journal, was actually somewhat lower than previous years, with half of these being requested for reviewers and the rest coming unsolicited. An equal number of books was sent out to reviewers, but there are still many available titles on my shelves. The number of reviews published in Volume 100 equalled the previous record of 86 books, set in 1981.

There are some reviewers who have procrastinated in not completing their reviews on time. These people are requested to please remedy the situation. The delays

involved hurt our reputation with the publishers who provide complimentary copies of expensive books.

New reviewers are always needed. Anyone interested should send your name along with background on your areas of interest to the book-review editor. Books can be selected from those marked as available in the New Titles listing. Appropriate titles can also be requested from the publishers. Reviewers must commit to completing a review within two to three months of receiving the book. Guidelines for reviewers are available on request.

WILSON EEDY
Book-review Editor

R.R. 1, Moffat,
Ontario L0P 1J0

Notice of The Ottawa Field-Naturalists' Club 109th Annual Business Meeting 12 January 1988

The 109th Annual Business Meeting of the Ottawa Field-Naturalists' Club will be held in the auditorium of the Victoria Memorial Museum Building, Metcalfe and MacLeod streets, Ottawa on Tuesday, 12 January 1988 at 2000 h.

MONA COLEMAN
Recording Secretary

Call for Nominations for the 1988 Council of The Ottawa Field-Naturalists' Club

A nominating committee has been chosen by the Council to nominate persons for election to offices and membership of the Council for the year 1987, as required by the Constitution.

We would like to remind Club members that they also may nominate candidates as officers and other members of Council. Such nominations require the signatures of the nominator and seconder, and a statement of willingness to serve in the specified position by the nominee. Nominations should be sent to the Nominating Committee, The Ottawa Field-

Naturalists' Club no later than 1 December 1987.

The Committee will also consider any suggestions for nominees which members wish to submit to it by 1 December 1987. It would be helpful if some relevant background on the proposed nominees were provided along with the suggested names.

BARBARA CAMPBELL
Chairman, Nominating Committee
The Ottawa Field Naturalists' Club, Post Office Box 3264,
Postal Station C, Ottawa, Ontario K1Y 4J5

Call for Nominations for the 1988 Ottawa Field-Naturalists' Club Awards

Nominations are requested from Club members for the following awards:

Honorary Membership
Member of the Year Award
Service Award
Conservation Award
Anne Hanes Natural History Award

With the exception of honorary members all nominees must be members in good standing.

Nominations and supporting rationale should be submitted no later than 15 December 1987 to

DANIEL F. BRUNTON
Chairman, Awards Committee

Description of these awards is given in *The Canadian Field-Naturalist* 96(3): 367(1982).

The Ottawa Field-Naturalists' Club, Post Office Box 3264,
Postal Station C, Ottawa, Ontario K1Y 4J5

A Continuing Salute: William James Cody: Managing *The Canadian Field-Naturalist*

Don't be misled — this notice is neither token praise for the departing nor an eulogy to the departed: Bill Cody is very much with us and we are here simply recognizing yet another benchmark for him.

In 1979 The Ottawa Field-Naturalists' Club made him an honorary member for contributions to Canadian botany and 33 years of service to the Club (1980. *Canadian Field-Naturalist* 94(3): 345). Although appreciative and characteristically surprised by the tribute, Bill (also characteristically) never broke stride, and now in 1987 when the awards committee wanted to mark his 41st year of continuing dedication they have had to resort to this extraordinary salute. We are fairly confident of again surprising him and even more certain that it will not diminish his focus on immediate priorities as is his style (already I can hear him questioning who is to be billed page charges for *this* item).

Bill is first of all a botanist, and a productive one. Born 2 December 1922 in Hamilton, Ontario, he came to the Central Experimental Farm at Ottawa on 1 October 1946, the year he received a B.A. from McMaster University. He began as a Senior Agricultural Assistant, and within a year was elevated to a Principal Agricultural Assistant, later to Technical Officer, then to Agricultural Research Scientist and finally in 1967 to Research Scientist. His field work began in 1948 on Southampton Island and subsequently expanded within the Northwest Territories, to the Yukon, to Alaska, and to every province except Newfoundland. To date he has made over 35 000 plant collections. In 1959, when the Plant Research Institute was created, he became curator of the Vascular Plant Herbarium and supervised its growth from 370 305 mounted specimens at that time to the present 800 000 specimens. From 1963 to 1983 he also produced the "Index Seminum" listing the seeds that had been collected locally and across Canada and available to arboreta and botanical gardens throughout the world. Bill's first paper was in 1950 (fittingly in *The Canadian Field-Naturalist* 64: 90–92) and so far he has authored or coauthored 200 publications (84 research in refereed journals or books, 45 miscellaneous, and 71 book reviews). Among his larger contributions are *The ferns of the Ottawa District* (1978. Agriculture Canada Publications 974. 112 pp.) and the monumental *The vascular plants of continental Northwest Territories* (1980. National Museum of Natural Sciences. 667 pp.), the latter coauthored with the late Alf Erling Porsild (see: 1978. *The Canadian Field-Naturalist* 92: 299–304). Bill currently has in press a *Manual of the plants of Riding Mountain National Park, Manitoba*, and *The ferns and fern-allies of Canada*.

Among items in preparation are *The vascular flora of the Yukon Territory* and a *List of type specimens of vascular plants in the Department of Agriculture Ottawa (DAO) herbarium*. Bill was a coauthor of *Systematics in Agriculture Canada at Ottawa 1886–1986*, Number 28 in the Historical Series, Biosystematics Research Centre, Agriculture Canada, which is a rich source of information on all staff researchers past and present in systematic botany and in entomology at The Farm.

Bill joined the Ottawa Field-Naturalists' Club soon after coming to Ottawa and took out a life membership in 1950. He was appointed assistant to the treasurer in 1947. He was elected to Council in 1948 and has served continuously ever since. He was appointed to the post of business manager when it was created in 1948 to assume responsibilities formerly undertaken by a curator of back numbers and to relieve the editor of *The Canadian Field-Naturalist* of handling reprint orders, mailing lists, and associated tasks. The duties originally also included managing the entire business of the Club, but, with the increasing size of the journal, were reduced to include only the latter in 1968. Bill has thrived on this workload



Bill Cody, curator, research botanist and Business Manager of *The Canadian Field-Naturalist*, at his office in the William Saunders Building, Central Experimental Farm, Ottawa, 28 January 1986. Courtesy Daniel F. Brunton.

through 40 years. It is this continuity and competence during the changing editorship of the journal (see 1986. *The Canadian Field-Naturalist* 100(3): 423–426) which has contributed in large measure to the success of *The Canadian Field-Naturalist* and often to its very financial survival. It has smoothed editorial transitions and kept the general objectives of the journal foremost.

A salute to Bill is incomplete without one simultaneously to Lois, whom he married in 1950. They have teamed not just to raise a family together but Lois has actively supported his botanical research and his involvement with the Ottawa Field-Naturalists' Club. She has also made a direct contribution as assistant to the treasurer in 1969–74 and again from 1978 to the present. It is Lois who keeps the current circulation lists up-to-date, handles all subscription billings, and answers all those

plaintive queries in the past few years about copies of issues assumed to be missing but in reality late in publication as the current editor wrestled toward a proper schedule.

My pleasure in writing this appreciation for the awards committee is reinforced by my debt to Bill for his consistent encouragement and his good humour, whatever the difficulties of the moment throughout my two spells as editor. This state is only tempered by the certain knowledge that at any moment the phone or doorbell may ring (my office is geographically situated between the Saunders building at the Central Experimental Farm and Bill's home) and chipper tones announce: "I was just talking to Emil at M.O.M., and Eddie could process some copy now, if ..."

FRANCIS R. COOK
Editor

Errata: *The Canadian Field-Naturalist* 100(1) and 100(3)

Corrections should be noted for two articles on The Ottawa Field-Naturalists' Club publications:

In "The 'One Hundredth' Volume of *The Canadian Field-Naturalist*" in 100(1): 140–142 on page 140, line 18, it erroneously stated that the first number of *The Ottawa Naturalist* was subtitled Transactions "number 3". This is a lapsus for "volume 3" as is apparent later in the text. It is also apparent that on line 24 "J. W." should read "W. J."

In "Additions to the documentation of the publication history of *The Canadian Field-Naturalist* and its predecessors" 100(3): 423–426, the reference to the 1954 paper by "Boivin and Cody" on pages 423 and 424 and its citation on page 425 has the order of authors reversed, in confusion with the sequence in a

subsequent paper by the same authors. The correct citations are:

Cody, W. J., and B. Boivin. 1954. The Canadian Field-Naturalist and its predecessors. *Canadian Field-Naturalist* 68(3): 127–132.

Boivin, B., and W. J. Cody. 1955. Bibliographic survey of James Fletcher's *Flora Ottawensis*. *Canadian Field-Naturalist* 69(1): 79–82.

The individual authors are both grateful and apologetic to W. J. Cody who drew our attention to the latter editorial lapsus.

FRANCIS R. COOK
Editor

Inflation and *The Trumpeter*

In 100(3): 455 of *The Canadian Field-Naturalist* a review appeared of *The Trumpeter: Voices from the Canadian Ecophilosophy Network* by Don E. McAllister. Unfortunately between submission and publication the subscription prices quoted have increased. The current cost for individual membership is \$8.00, and a complete set of past newsletters is \$8.00 plus \$1.00 postage. Other subscription rates are:

Overseas 'surface \$10.00, library/public agency/overseas air \$12.00, contributing \$15.00, sustaining \$25.00, patron \$35.00.

Order from: Light Star Press, 1138 Richardson Street, Victoria, British Columbia V8V 3C8.

ALAN R. DREUGSON,
Editor, *The Trumpeter*

A Tribute to HOMER JOHN SCOGGAN, 1911–1986

MICHAEL J. SHCHEPANENK

Botany Division, National Museum of Natural Sciences, National Museums of Canada, Ottawa K1A 0M8

Homer John Scoggan, known best as the author of the four-volume *Flora of Canada* and several major provincial floras, died in Ottawa, Ontario, on 28 June 1986. Although he spent almost his entire life in Canada, he was born in Macedonia, Iowa, 9 March 1911. His father, Edward, was a Methodist minister, also born in Iowa, but of old English ancestry. His mother, Almeda Roy, was of French-Canadian heritage. Homer was the younger of two children, but his sister passed away at an early age during an influenza epidemic. Upon the death of his father, Homer and his mother immigrated to the province of Québec and settled in Montréal in 1920.

Homer attended primary and secondary school in Montréal where he became fluently bilingual in English and French. In 1930, Homer graduated with the High School of Montréal with the H. Aspinwall Howe Medal and Prize, and in the fall he entered McGill University, Montréal, where he received his B.Sc. in 1934, M.Sc. in 1935, and Ph.D. in 1942. Homer majored in Botany and received his Ph.D. under the direction of Professor V. C. Wynne-Edwards.

For his degree, Homer carried out extensive botanical studies in the Gaspé, culminating in his thesis "Ecological studies of the Arctic-Alpine flora of the Gaspé Peninsula and of Bic, Québec". In addition to his degrees, Homer received a First Class High School Teaching Diploma from McGill and the Highest Grade Certificate in Theoretical Music from the McGill Conservatorium.

While working towards his Ph.D., Homer held the post of the Head of the Science Department at the Strathcona Academy, Outremont, Québec, where he taught biology, chemistry, physics and mathematics. It was at this time that he married Sybil Harrison (23 December 1938). Sybil was a good match for Homer's dynamic energy and intellect. She herself had received her M.Sc. from McGill and later would obtain her Ph.D. in biochemistry from the University of Ottawa. In 1940, Homer accepted a position as instructor at the Montreal Botanical Garden where he worked under Professor Jacques Rousseau. In the evenings, during the same period, he taught night school at Sir George William College (chemistry and mathematics) and at the Montreal Technical Institute (mechanics), and still found time to complete his Ph.D. in 1942.

In 1946, he obtained the post of Assistant Professor of Botany, Macdonald College (McGill University), where he conducted lectures and laboratories in first year general botany and third and fourth year physiology, taxonomy, and morphology. In addition, he gave nature study courses at the Macdonald College School for Teachers. In 1947, Homer applied for and, on 3 June, received the position of Biologist at the Botany Division of the National Museum of Canada (now the National Museum of Natural Sciences, National Museums of Canada) in Ottawa. He worked at the Museum for 25 years serving as a Research Scientist until he retired in 1972.

At first, Homer devoted most of his time to completing his Gaspé Flora, published in 1950. Upon joining the Museum staff, Homer donated his personal herbarium of over 2000 specimens from the Gaspé Peninsula to the National Herbarium. In 1948 he initiated his Flora of Manitoba project. During that summer, he led a field party that surveyed from Norway House to Cross Lake and across northern Lake Winnipegosis in northern Manitoba. The following year he surveyed the water route extending along the Nelson, Echimamish and Hayes rivers from Norway House off the north end of Lake Winnipeg to York Factory on Hudson Bay. The return trip was made by ascending the Nelson River to Limestone Rapids, Wekusko and Tramping lakes.

Homer teamed up with his museum colleague W. K. W. Baldwin in the summer of 1950. Together they botanized the prairie district of southwestern Manitoba, the wooded area between Riding Mountain and The Pas, and the barren ground region of Nejanilini Lake, Manitoba, and Baralzan Lake, Keewatin, N.W.T. During the summer of 1951, Homer continued his field work in the prairie and forested regions of Manitoba as far north as Pine Falls, Riverton, Gypsumville, and Flin Flon. He did not visit the field in 1952 but concentrated on herbarium and bibliographic research towards his Flora of Manitoba. He returned to Manitoba in 1953 to complete his investigation of that province by surveying the prairie vegetation of the south. In 1954, he stayed in Ottawa and completed the Flora of Manitoba.

1954 was also the year Homer commenced work on a proposed flora of maritime eastern Canada. In the

summers of 1955 and 1956 he surveyed accessible areas of New Brunswick and eastern Québec. Although minor field work was undertaken in the Maritimes from 1957 through 1959, Homer mainly concentrated on herbarium research at institutions along the eastern seaboard. In addition, he conducted field work in 1958 at Churchill, Manitoba, in preparation for leading an excursion of the IX International Botanical Congress held in Montréal in 1959. In 1960, Homer widened the scope of his maritime flora to include central Canada and during the summer carried out extensive surveys in southern Ontario. From 1961–1963, he apparently did no major field work but concentrated on producing a flora of central and eastern Canada which was completed and submitted in 1963.

Homer began work on a British Columbia and Alberta flora in 1964. During the summer, accompanied by his son Hugh, he collected and studied the vegetation of the southern part of those two western provinces. By 1965, it was realized that the high production costs as well as the questionable market for a flora of central and eastern Canada prohibited its publication at that time. This, however, did not dampen Homer's spirits as he entered into a new ambitious project, which had been his real goal and dream for some time: a *Flora of Canada*. Each year from 1965–1968, he made trips to British Columbia and Alberta to study the flora at different times of the year and to test his preliminary keys. In 1969, he avoided field work and concentrated on his manuscript, which was completed in 1970. That summer he travelled from Ontario to the west coast, taking photographs with which he planned to document his flora, photographs that unfortunately proved to be unusable. He spent 1971 revising and updating the text. During the summer, however, because of his previous experience in western Canada, he was asked to act as scientific advisor for a design and display team filming and gathering information for the Museum's future Botany Hall. On 31 December 1971, Homer finished work at the Museum and took leave until his official retirement from the government on 7 June 1972.

The year following his retirement, Homer and his wife Sybil moved to Vernon, British Columbia, but returned to eastern Canada in 1974 to settle in Rimouski, Québec. On 28 February 1975 Sybil passed away and Homer returned to Ottawa to be closer to his children and grandchildren. Shortly after his arrival in Ottawa, he received news that his *Flora of Canada* would be accepted for publication with some revisions to the text, and for the next three years he relentlessly dedicated himself to this task. Upon the publication of the final volume in 1979, Homer's

interest in Botany was complete and he devoted himself to other pursuits. Seeing his grandchildren was his top priority, and to those far away he spent long hours composing letters and even poetry. His life-long love of music continued and grew stronger. He enjoyed playing piano, and frequently listened to music from his large record collection, especially the works of Johann Sebastian Bach. After many years of studying serious scientific books, he now entertained himself with reading mysteries and war novels. His botanical training and interests did not wain altogether, however; even in his final year Homer was quick to give assistance to fellow botanists, such as Dr. M. Kuc, when they needed counselling on a particular project.

During his scientific career, Homer was a member of many societies and organizations. Of special note was his involvement with Agricultural Institute of Canada, Québec Society for the Protection of Plants, Arctic Circle, Canadian Museums Association and the Canadian Botanical Association. In addition, from 1946 to 1947, he served as Vice-President of the Société Canadienne d'Histoire Naturelle based at the University of Montréal. Upon arriving in Ottawa (1947), Homer immediately joined The Ottawa Field-Naturalists' Club. From 1948 to 1957, he was the Club's secretary, and he continued to serve as a member of Council from 1958 to 1963. In 1948 he was on the committee that founded the Macoun Field Club. This club, co-sponsored by the National Museum of Natural Sciences, was created to encourage and assist school-age children in developing their interest in natural history. Homer served as chairman of the Macoun Field Club from 1958 to 1960.

Homer could be described as a quiet and serious person who gave unceasing dedication to his work and projects. If anyone challenged him on a point he would openly speak his mind, but the next time Homer encountered that person he would greet him with a friendly smile, the settled problem having been forgotten. His contemporary colleagues and field companions, among them Drs. James H. Soper and John M. Gillett, remarked on how helpful and agreeable a person he always was. At the herbarium, even though he was under pressure to complete his *Flora of Canada*, Homer would put his own research aside to assist a fellow botanist with plant identification problems or donate his time to herbarium functions such as filing specimens or helping in the expansion of the plant collection. It seems Homer always found the time to assist someone and still bring his own projects to a successful conclusion. Homer's most notable contributions to science and the Canadian people were his monumental floras of Gaspé, Manitoba, and Canada.



Homer John Scoggan

Homer is survived by his daughter Elizabeth (Mrs. Robert Bradley) of Kinburn, Ontario, with grandchildren Chris, Charlotte, and Julia, and his sons John of Victoria, British Columbia, and Hugh of Kitchener, Ontario, with grandchildren Kiley and Kevin.

List of Publications of Homer J. Scoggan

- Scoggan, H. J.** 1942. Ecological studies of the Arctic-Alpine flora of the Gaspé Peninsula and of Bic. Ph.D. thesis, McGill University, Montreal.
- Scoggan, H. J.** 1948. Families of flowering plants. *Canadian Nature* 10: May-June, pp. 102-105; September-October, pp. 134-137.
- Scoggan, H. J.** 1949. Pioneer plants. *Canadian Nature* 11: January-February, pp. 22-25.
- Scoggan, H. J.** 1949. Families of flowering plants. *Canadian Nature* 11: May-June, pp. 86-89; September-October, pp. 114-117.
- Scoggan, H. J.** 1949. Chestnuts. *Canadian Nature* 11: September-October, pp. 104-105.
- Scoggan, H. J.** 1950. Botanical investigations in central Manitoba. *National Museum of Canada, Bulletin* 118: 84-92.
- Scoggan, H. J.** 1950. The flora of Bic and the Gaspé Peninsula, Québec. *National Museum of Canada, Bulletin* 115 (Biological Series 39): 1-339.
- Scoggan, H. J.** 1950. Families of flowering plants. *Canadian Nature* 12: May-June, pp. 98-101; September-October, pp. 134-139.
- Scoggan, H. J.** 1950. Watch trees for their catkins. *Canadian Nature* 12: May-June, pp. 107-111.
- Scoggan, H. J.** 1950. Wild mushrooms. *Canadian Nature* 12: May-June, pp. 88-89.
- Scoggan, H. J.** 1951. Families of flowering plants. *Canadian Nature* 13: May-June, pp. 102-105.
- Scoggan, H. J.** 1951. Botanical Surveys in central and northern Manitoba. *Arctic Circular Number* 4: 37-45.
- Scoggan, H. J.** 1951. Botanical investigations along the Hayes River Route, northern Manitoba. *National Museum of Canada, Bulletin* 123: 139-161.
- Scoggan, H. J.** 1952. Botanical investigations in Manitoba in 1950. *National Museum of Canada, Bulletin* 126: 208-227.
- Scoggan, H. J.** 1953. Botanical Investigations in the glacial lakes Agassiz-Souris basins. *National Museum of Canada, Bulletin* 128: 103-109.
- Scoggan, H. J.** 1956. Canada's wildflowers. *Canadian Nature* 18: September-October, pp. 128-130.
- Scoggan, H. J.** 1957. Families of flowering plants. *Canadian Nature* 19: May-June, pp. 88-90.
- Scoggan, H. J.** 1957. Flora of Manitoba. *National Museum of Canada, Bulletin* 140 (Biological Series 47): 1-619.
- Scoggan, H. J.** 1958. Families of flowering plants. *Canadian Audubon* 20: September-October, pp. 118-119.
- Scoggan, H. J.** 1959. Some Canadian wild flowers. *Canadian Geographical Journal* 58(4): 114-117.
- Scoggan, H. J.** 1959. Some flowers of Canada. *Canadian Geographical Journal* 58(5): 161-165.
- Scoggan, H. J.** 1959. The native flora of Churchill, Manitoba; with notes on the history, geology, and climate of the area [Guide book]. *National Museum of Canada, Ottawa*. 51 pages.
- Scoggan, H. J.** 1966. The Flora of Canada. Pages 35-61 in *Canada Year Book 1966*. Dominion Bureau of Statistics, Ottawa.
- Scoggan, H. J.** 1978-79. The Flora of Canada. Four volumes. *National Museum of Natural Sciences, Publications in Botany Number* 7, Ottawa.

Rare and Endangered Fishes and Marine Mammals of Canada: COSEWIC Fish and Marine Mammal Subcommittee Status Reports: III.

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Campbell, R. R. *Editor*. 1987. Rare and endangered fishes and marine mammals of Canada: COSEWIC fish and marine mammal subcommittee status reports: III. *Canadian Field-Naturalist* 101(2): 165-170.

Nineteen status reports, representing the 1985 and 1986 fish and marine mammal status assignments by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), have been prepared for publication. Subcommittee activities are briefly discussed and species lists presented both for those animals for which reports are in progress (57 fish and 23 marine mammals) and those for which reports are required (30 fish, 10 marine mammals and 1 marine mollusc).

Dix-neuf rapports de statut représentant toute les données de statut aux poissons et aux mammifères marins nommés en 1985 et en 1986 par le Comité sur le statut des espèces fauniques menacées d'extinction au Canada ont été préparés pour publication. Les activités du sous-comité sont brièvement discutées avec des tableaux qui montrent des rapports en cours (57 poissons et 23 mammifères marins) et les espèces pour lesquelles on en a besoin encore (30 poissons, 10 mammifères marins et 1 mollusque marin).

Key Words: Rare and endangered species, fish, marine mammals, COSEWIC.

As indicated in previous submissions (Campbell 1984, 1985), the intent of the Subcommittee on Fish and Marine Mammals is to publish the status reports (on those species of fish and marine mammals) which the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has reviewed and approved and used as a basis of assigning status to species in jeopardy in Canada. The group of 19 reports presented in this issue represent the fish and marine mammal component of those species assigned status in 1985 and 1986* and it is hoped that in succeeding volumes we will be able to offer those reports reviewed in future years (Table 1 presents those species assigned status to April 1986).

Progress

From the outset, COSEWIC was charged with making available to all Canadians supporting information on each species classified (Cook and Muir 1984). In the spirit of this charge, the Fish and Marine Mammal Subcommittee has, through a fortuitous set of circumstances, been able to use this vehicle as one step in achieving this objective. Both in 1984 and 1985 [see *Canadian Field-Naturalist* 98(1):63-133 and 99(3): 404-450] a series of reports

was published and the response to the publication and requests for further information on the organization provided the encouragement to continue the process and broaden the scope of the exercise.

The response has not only been in requests for reprints or further information, but also in additional suggestions to our list of species for consideration (see Table 2) which has been considerably extended. Although some of these species may be of no immediate concern, the Subcommittee will, as opportunity allows, attempt to document their distribution and abundance to determine their status in Canada.

The marine mammal list (Table 2) has been extended to include all whales, dolphins and porpoises known to Canadian waters since these are species of international concern to the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) and the International Whaling Commission (IWC). There are currently 30 status reports on fish species, one on a marine mollusc and 10 on marine mammal species under review or in preparation (Table 3). Most of these should be assigned status in 1987. In addition to soliciting further status reports on species of concern, the Subcommittee has continued to obtain updates on the status of selected species as new information becomes available from independent studies. In the past year, for example, we received new information on the Humpback Whale which permitted a downlisting of the North Atlantic stock from Threatened to Rare (see

*The updated status report on the current status of the Bowhead Whale in the western Canadian arctic is not presented here as it is already in publication elsewhere (see Mitchell and Reeves 1986). The status report for the Narwhal was a preliminary report and does not appear herein.

TABLE 1. Fish and marine mammal species with assigned COSEWIC status to April 1986.

Species	Scientific Name	Status	Date Assigned
Fish			
Lake Sturgeon	<i>Acipenser fulvescens</i>	NIAC ¹	April 1986
Blueback Herring	<i>Alosa aestivalis</i>	NIAC	April 1980
Lake Lamprey	<i>Lampetra macrostoma</i>	Rare	April 1986
Shortnose Sturgeon	<i>Acipenser brevirostrum</i>	Rare	April 1980
Spotted Gar	<i>Lepisosteus oculatus</i>	Rare	April 1983
Silver Chub	<i>Hybopsis storeriana</i>	Rare	April 1985
Bigmouth Shiner	<i>Notropis dorsalis</i>	Rare	April 1985
Pugnose Shiner	<i>Notropis anogenus</i>	Rare	April 1985
Silver Shiner	<i>Notropis photogenis</i>	Rare	April 1983
Pugnose Minnow	<i>Notropis emiliae</i>	Rare	April 1985
Speckled Dace ³	<i>Rhinichthys osculus</i>	Rare	April 1980 ³
Central Stoneroller	<i>Camptostoma anomalum</i>	Rare	April 1985
Blackstripe Topminnow	<i>Fundulus notatus</i>	Rare	April 1985
Spotted Sucker	<i>Minytrema melanops</i>	Rare	April 1983
River Redhorse	<i>Moxostoma carinatum</i>	Rare	April 1983
Brindled Madtom	<i>Noturus miurus</i>	Rare	April 1985
Giant Stickleback ²	<i>Gasterosteus</i> sp.	Rare	April 1980
Charlotte Unarmoured Stickleback ²	<i>Gasterosteus</i> sp.	Rare	April 1983
Shorthead Sculpin	<i>Cottus confusus</i>	Threatened	Nov. 1983
Acadian Whitefish ²	<i>Coregonus canadensis</i>	Endangered	April 1983
Salish Sucker	<i>Catostomus</i> sp.	Endangered	April 1986
Gravel Chub	<i>Hybopsis x-punctata</i>	Endangered	April 1985
Longjaw Cisco	<i>Coregonus alpenae</i>	Extinct	April 1985
Blue Walleye	<i>Stizostedion vitreum glaucum</i>	Extinct	April 1985
Marine Mammals			
Hooded Seal	<i>Cystophora cristata</i>	NIAC	April 1986
Northern Elephant Seal	<i>Mirounga angustirostris</i>	NIAC	April 1986
Narwhal	<i>Monodon monoceros</i>	NIAC	April 1986
Beaufort Sea Beluga	<i>Delphinapterus leucas</i>	NIAC	April 1986
Blue Whale ³	<i>Balaenoptera musculus</i>	Rare	April 1983
Sea Otter ⁶	<i>Enhydra lutris</i>	Endangered	May 1978
Humpback Whale ⁴	<i>Megaptera novaeangliae</i>	North Pacific; Threatened	April 1982
		North Atlantic; Rare	April 1985
Bowhead Whale ⁵	<i>Balaena mysticetus</i>	Endangered	April 1980
Right Whale ⁶	<i>Eubalaena glacialis</i>	Endangered	April 1980/ April 1985
St. Lawrence River Beluga	<i>Delphinapterus leucas</i>	Endangered	April 1983
Sea Mink	<i>Mustela macrodon</i>	Extinct	April 1985

¹NIAC: Not In Any [COSEWIC] Category (i.e. not in jeopardy).²Endemic to Canada.³Updated April 1984: no status change.⁴Updated April 1985: North Atlantic stock downlisted to Rare.⁵Updated April 1985 - no status change.⁶Updated April 1986 - no status change.

TABLE 2. Fish and marine mammal species of interest to COSEWIC (not by priority).

Species	Scientific Name	Possible Status
Fish		
Northern Brook Lamprey	<i>Ichthyomyzon fossor</i>	Rare
Chestnut Lamprey	<i>Ichthyomyzon castaneus</i>	Rare
Darktail Lamprey	<i>Lethenteron alaskense</i>	Rare
Bull Trout	<i>Salvelinus confluentus</i>	Rare (Alberta)
		Common in British Columbia
Red [Arctic] Char†	<i>Salvelinus alpinus</i> spp.	?
Bering Cisco	<i>Coregonus laurettae</i>	? (Yukon)
Lake Herring	<i>Coregonus artedii</i>	Endangered in lakes Erie and Ontario but widespread elsewhere
Lake Whitefish	<i>Coregonus clupeaformis</i>	Threatened in lakes Erie and Ontario but widespread elsewhere
Mira Whitefish*	<i>Coregonus</i> sp.	Rare
Spring Cisco*	<i>Coregonus</i> sp.	Rare (Ontario and Quebec)
Pygmy Whitefish	<i>Prosopium coulteri</i>	Rare
Round Whitefish	<i>Prosopium cylindraceum</i>	Rare in lakes Huron and Ontario but widespread elsewhere
Pygmy Longfin Smelt*	<i>Spirinchus thaleichthys</i>	Rare (landlocked population in Harrington Lake, British Columbia); anadromous populations widespread
Chain Pickerel	<i>Esox niger</i>	Rare
Grass Pickerel	<i>Esox americanus vermiculatus</i>	Rare
Redfin Pickerel	<i>Esox americanus americanus</i>	Rare
Bluntnose Minnow	<i>Pimephales notatus</i>	Rare (Manitoba)
Cutlips Minnow	<i>Exoglossum maxillingua</i>	?
Eastern Silvery Minnow	<i>Hybognathus nuchalis regius</i>	Rare
Western Silvery Minnow	<i>Hybognathus argyritis</i>	?
Hornyhead Chub**	<i>Nocomis biguttatus</i>	Rare
River Chub**	<i>Nocomis micropogon</i>	Rare
Ghost Shiner	<i>Notropis buchanani</i>	Rare
Redfin Shiner	<i>Notropis umbratilis</i>	Rare
Striped Shiner	<i>Notropis chrysocephalus</i>	Rare
Nooky Dace	<i>Rhinichthys cataractae</i> spp.	Rare
Leopard Dace	<i>Rhinichthys falcatus</i>	?
Liard Hotspring Lake Chub	<i>Couesius plumbeus</i>	Rare (Liard Hotspring population) but species widespread elsewhere
Mountain Sucker	<i>Catostomus platyrhynchus</i>	Rare
Lake Chubsucker	<i>Erimyzon sucetta</i>	Rare
Bigmouth Buffalo	<i>Ictiobus cyprinellus</i>	Rare
Black Buffalo	<i>Ictiobus niger</i>	?
Golden Redhorse	<i>Moxostoma erythrurum</i>	Rare
Flathead Catfish	<i>Pylodictis olivaris</i>	?
Banded Killifish	<i>Fundulus diaphanus</i>	Rare (Newfoundland, Manitoba); common elsewhere
Margined Madtom	<i>Noturus insignis</i>	?
Northern Madtom	<i>Noturus stigmosus</i>	Rare
Brook Silverside	<i>Labidesthes sicculus</i>	?
Texada Stickleback*	<i>Gasterosteus</i> sp.	Rare
Redbreast Sunfish	<i>Lepomis auritus</i>	Rare (New Brunswick)

TABLE 2. Species of interest to COSEWIC (*concluded*).

Species	Scientific Name	Possible Status
Orangespotted Sunfish	<i>Lepomis humilis</i>	Rare
Warmouth	<i>Lepomis gulosus</i>	?
Eastern Sand Darter	<i>Ammocrypta pellucida</i>	Rare
Greenside Darter**	<i>Etheostoma blennioides</i>	Rare
Least Darter**	<i>Etheostoma microperca</i>	?
Tessellated Darter	<i>Etheostoma olmstedii</i>	Rare
Channel Darter	<i>Percina copelandi</i>	Rare
River Darter**	<i>Percina shumardi</i>	Rare
Y-Prickleback	<i>Allolumpenus hypochromus</i>	Rare (British Columbia)
Striped Bass	<i>Morone saxatilis</i>	Endangered
Cultus Pygmy Coastrange Sculpin*	<i>Cottus aleuticus</i>	Threatened
Spoonhead Sculpin	<i>Cottus ricei</i>	Rare (Ontario)
Fourhorn Sculpin	<i>Moxocephalus quadricornis</i>	Rare (Ontario)
Spinynose Sculpin	<i>Asemichthys taylori</i>	Rare (British Columbia)
Pixy Poacher*	<i>Ocella impi</i>	Rare (British Columbia)
Bering Wolffish	<i>Anarhichas orientalis</i>	Rare
Blackline Prickleback	<i>Acantholumpenus mackayi</i>	Rare
Marine Mammals		
Baird's Beaked Whale	<i>Berardius bairdii</i>	?
Northern Bottlenose Whale	<i>Hyperoodon ampullatus</i>	?
Sei Whale	<i>Balaenoptera borealis</i>	Rare (North Atlantic)
Minke Whale	<i>Balaenoptera acutorostrata</i>	Rare?
Sperm Whale	<i>Physeter catodon</i>	NIAC?
Cuvier's Beaked Whale**	<i>Ziphius cavirostris</i>	?
Blainville's Beaked Whale**	<i>Mesoplodon densirostris</i>	?
Hubb's Beaked Whale	<i>Mesoplodon carlhubbsi</i>	Rare
Stejneger's Beaked Whale	<i>Mesoplodon stejnegeri</i>	Rare
True's Beaked Whale**	<i>Mesoplodon mirus</i>	?
Long-finned Pilot Whale	<i>Globicephala melaena</i>	?
Killer Whale**	<i>Orcinus orca</i>	?
False Killer Whale**	<i>Pseudorca crassidens</i>	?
Harbour Porpoise**	<i>Phocoena phocoena</i>	?
Dall's Porpoise	<i>Phocoenoides dalli</i>	Rare
Atlantic White-sided Dolphin**	<i>Lagenorhynchus acutus</i>	?
Pacific White-sided Dolphin**	<i>Lagenorhynchus obliquidens</i>	?
White-beaked Dolphin**	<i>Lagenorhynchus albirostris</i>	?
Common Dolphin**	<i>Delphinus delphis</i>	?
Northern Right Whale Dolphin**	<i>Lissodelphis borealis</i>	?
Risso's Dolphin**	<i>Grampus griseus</i>	?
Striped Dolphin**	<i>Stenella coeruleoalba</i>	?
Bottlenose Dolphin	<i>Tursiops truncatus</i>	?

†Landlocked populations in Quebec, New Brunswick, Labrador and Newfoundland.

*Endemic to Canada

**Not of immediate concern

TABLE 3. Fish and marine mammal species for which status reports are in preparation or under review: April 1986.

Species	Scientific Name	Proposed Status
Fish		
Paddlefish	<i>Polyodon spathula</i>	Extirpated
Atlantic Sturgeon	<i>Acipenser oxyrhynchus</i>	?
Green Sturgeon	<i>Acipenser medirostris</i>	Rare
White Sturgeon	<i>Acipenser transmontanus</i>	?
Aurora Trout*	<i>Salvelinus fontinalis timagamiensis</i>	Extirpated
Atlantic Salmon	<i>Salmo salar</i>	?
Blackfin Cisco	<i>Coregonus nigripinnis</i>	Threatened
Bloater	<i>Coregonus hoyi</i>	Rare
Deepwater Cisco	<i>Coregonus johannae</i>	Endangered
Kiyi	<i>Coregonus kiyi</i>	Rare
Simcoe Lake Whitefish*	<i>Coregonus clupeaformis</i> spp.	Threatened
Opeongo Whitefish*	<i>Coregonus</i> sp.	Threatened
Shortnose Cisco	<i>Coregonus reighardi</i>	Threatened
Shortjaw Cisco	<i>Coregonus zenithicus</i>	Extinct (lakes Huron, Erie and Ontario)
Squanga Whitefish*	<i>Coregonus</i> sp.	Threatened
Pygmy Smelt	<i>Osmerus spectrum</i>	Rare
Banff Longnose Dace*	<i>Rhinichthys cataractae smithi</i>	Endangered
Umatillus Dace	<i>Rhinichthys umatillus</i>	Rare
Redside Dace	<i>Clinostomus elongatus</i>	Threatened
Silver Shiner†	<i>Notropis photogenis</i>	Rare
Jasper Longnose Sucker*	<i>Catostomus catostomus lacustris</i>	Rare
Black Redhorse	<i>Moxostoma duquesnei</i>	Endangered
Copper Redhorse	<i>Moxostoma hubbsi</i>	Threatened
River Redhorse†	<i>Moxostoma carinatum</i>	Rare
Green Sunfish	<i>Lepomis cyanellus</i>	Rare
Longear Sunfish	<i>Lepomis megalotis</i>	Rare
Deepwater [Fourhorn] Sculpin	<i>Myoxocephalus thompsoni</i>	Extirpated (Lake Ontario, Lake Erie); widespread elsewhere
Enos Lake Stickleback*	<i>Gasterosteus</i> sp.	Threatened (British Columbia)
Pacific Sardine	<i>Sardinops sagax</i>	Rare
Bluefin Tuna	<i>Thunnus thynnus</i>	?
Marine Molluscs		
Northern Abalone	<i>Haliotis kamtschatkana</i>	?
Marine Mammals		
California Sea Lion	<i>Zalophus californianus</i>	Rare
Steller Sea Lion	<i>Eumetopias jubatus</i>	Rare?
Sowerby's Beaked Whale	<i>Mesoplodon bidens</i>	Rare
Walrus	<i>Odobenus rosmarus</i>	?
Cumberland Sound Beluga	<i>Delphinapterus leucas</i>	Threatened ?
Northern Québec Beluga	<i>Delphinapterus leucas</i>	Endangered
Bowhead Whale†	<i>Balaena mysticetus</i>	Endangered
Fin Whale	<i>Balaenoptera physalus</i>	Rare
Grey Whale:	<i>Eschrichtius robustus</i>	
Atlantic		Extirpated
Pacific		?
Sea Otter†	<i>Enhydra lutris</i>	Endangered

*Endemic to Canada.

†Status as indicated already assigned (see Table 1). These are updated status reports.

Table 1). Other updated reports on the Sea Otter, Bowhead Whale, River Redhorse, and Silver Shiner are in production (Table 3).

Concluding Remarks

The nineteen reports included in the following series are reports on the status of the populations of each species in Canada. Status was assigned by consensus of the COSEWIC Committee based on these reports and they are published under the name(s) of the original author(s). The reports have undergone minor editing to provide a brief introduction and some degree of consistency in format and presentation.

Acknowledgments

First and foremost are our thanks to the various authors who have so generously contributed their time and talents in support of COSEWIC and to the members of the Subcommittee (see Campbell 1984) for their unstinting efforts in reviewing the reports and their helpful comments.

The Subcommittee is grateful to World Wildlife Fund (Canada), the Canadian Wildlife Service, the Department of Fisheries and Oceans, and the

National Museums of Canada for their assistance in the process. A special mention to *The Canadian Field-Naturalist* for the encouragement and assistance in editing and publication and to all members of COSEWIC for their dedication and interest in the future of Canada's flora and fauna.

Literature Cited

- Campbell, R. R.** 1984. Rare and endangered fishes of Canada: the committee on the status of endangered wildlife in Canada (COSEWIC) fish and marine mammal subcommittee. *Canadian Field-Naturalist* 98(1): 71-74.
- Campbell, R. R.** 1985. Rare and endangered fishes and marine mammals of Canada: COSEWIC fish and marine mammals subcommittee status reports: II. *Canadian Field-Naturalist* 99(3): 404-408.
- Cook, F. R., and D. Muir.** 1984. The committee on the status of endangered wildlife in Canada (COSEWIC): history and progress. *Canadian Field-Naturalist* 98(1): 63-70.
- Mitchell, E., and R. R. Reeves.** 1986. Current status of the Bering Sea stock of bowhead whales. *Musk-ox* 34: 57-76.

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Status of the Lake Sturgeon, *Acipenser fulvescens*, in Canada*

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Houston, J. J. 1987. Status of the Lake Sturgeon, *Acipenser fulvescens*, in Canada. Canadian Field-Naturalist 101(2): 171-185.

The Lake Sturgeon (*Acipenser fulvescens*) the largest of Canada's freshwater fishes, is a primitive relict of the prehistoric past with a cartilaginous skeleton; it is, nevertheless, an important part of contemporary aquatic ecosystems. These slow growing fish are widely distributed in Canada and the United States. Although still common in most parts of their range, populations are nowhere as abundant as they were prior to becoming an important part of the commercial fisheries in 1860. Wherever fisheries were established, an initial period of high catches was followed by drastic and permanent decline. Evidence that the fish existed in great numbers is based on catches in the last quarter of the previous century, which exceeded 2 million tonnes annually. The total Canadian production today does not exceed 90 tonnes. Lake Sturgeon are a valuable resource: the wholesale value of the flesh is currently \$6-7/kg and that of caviar is \$17-22/kg. The reaction of sturgeon populations to exploitation is not fully understood. Their late maturity and intermittent spawning habits are certainly factors, as are certain critical habitat requirements. Dam construction and watershed alterations or degradation can seriously deplete the limited spawning habitat. Although still common throughout most of its range, the fish are rare in lakes Ontario and Winnipeg, and their future elsewhere can only be assured if strict management practices are followed and critical habitat is protected and preserved.

L'esturgeon jaune (*Acipenser fulvescens*) le plus gros des poissons dulçaquicoles présents dans les eaux canadiennes, est une espèce primitive panchronique de la période préhistorique avec une ossature cartilagineuse. Cependant, ce poisson à croissance lente constitue un élément important des écosystèmes aquatiques un peu partout au Canada et aux États-Unis. Même s'il est encore commun dans la partie majeure de son aire de répartition, il n'est plus nulle part aussi abondant qu'avant 1860, année où il est devenu une importante prise commerciale. Ainsi, dans chaque nouvelle pêcherie, on a vu une période initiale de prises élevées suivie de sérieux déclin permanents. Il est évident que l'esturgeon jaune était présent en grand nombre car la production annuelle au cours du dernier quart du siècle précédent dépassait 2 millions de tonnes. Aujourd'hui, la production canadienne totale ne dépasse pas 90 tonnes. L'esturgeon jaune est une ressource précieuse: en ce moment, la chair se vend de \$6 à \$7 le kilo et le caviar, de \$17 à \$22 le kilo. La réaction des populations d'esturgeon face à l'exploitation n'est pas complètement connue mais elle est reliée à une combinaison de facteurs relatifs au cycle vital et à l'environnement. La maturité tardive et la fraie irrégulière sont certainement des facteurs, tout comme certains besoins vitaux en matière d'habitat. La construction de barrages et les modifications ou la dégradation de bassins versants peuvent entraîner une baisse importante du nombre de frayères déjà limité. Quoiqu'il soit encore commun dans la plus grande partie de son aire de répartition, l'esturgeon jaune est rare dans les lacs Ontario et Winnipeg; ailleurs, seuls l'application de mesures de gestion rigoureuses et la protection et le maintien des habitats vitaux assureront sa survie.

Key Words: Lake Sturgeon, *Acipenser fulvescens*, caviar, freshwater fishes, freshwater sturgeon.

The Lake Sturgeon, *Acipenser fulvescens* Rafinesque 1817, is a fascinating species as it is not only of economic importance, but also, like all sturgeons, is a living fossil, retaining most of the features of its prehistoric ancestors. Impressions of fishes essentially sturgeon-like in form have been recorded in rocks dating from the upper Cretaceous, approximately 100 million years ago (Harkness and Dymond 1961). Among the primitive characteristics retained by sturgeons are the large body shields or plates in place of simple scales, a large cellular swim-bladder, a cartilaginous skeleton, and the heterocercal tail. In addition, the notochord is persistent, extending into

the lobe of the tail, and the vertebrae lack a centrum (Scott and Crossman 1973).

Lake Sturgeons (Figure 1) are slow-growing, freshwater species with delayed sexual maturity (up to 20 years or more depending on location and conditions). They are long-lived, surviving to 80 years or more (Scott and Crossman 1973), and are among the largest of the freshwater fishes of Canada. Mature specimens seen today attain weights of 4.6 - 36.4 kg and total lengths of 0.9 - 1.4 m, but larger fish are occasionally taken. One of the largest on record was taken from Lake Superior in 1922: it weighed 140.9 kg and measured 2.4 m (Scott and Crossman 1973). Another individual taken from Lake of the Woods in 1953 was thought to be 154 years of age and weighed 94.6 kg (MacKay 1963).

Although not usually considered a sport fish, the species has played an important role in the economics

*Not in jeopardy — NIAC (Not in any COSEWIC Category) April 1986.



FIGURE 1. Lake Sturgeon, *Acipenser fulvescens*.

of the freshwater fisheries and in some areas (e.g. Alberta) there are limited sport fisheries. The species was undoubtedly important to native peoples as a source of food before the coming of Europeans to the continent. Later, in the 19th century, it became an important commercial species.

Distribution

The Lake Sturgeon has one of the widest geographic ranges of any North American freshwater fish (Figure 2). Its range includes the three major watersheds: the Great Lakes, Hudson-James Bay, and the Mississippi River. In the United States, the Lake Sturgeon appears to have been limited to the Mississippi drainage and its larger tributaries south to Nebraska, Missouri and Alabama (Harkness and Dymond 1961; MacKay 1963; Scott and Crossman 1973).

In Canada, the Lake Sturgeon has been reported from the large rivers draining into Hudson Bay (Figure 3; known areas of historic fisheries indicated by circles) as far north as the Seal River on the west coast and Fort George on the east coast (Harkness and Dymond 1961). In the prairie provinces it is found in Alberta in the North Saskatchewan River as far upstream as Edmonton and commonly in the South Saskatchewan River (Roberge, personal communication); in Saskatchewan in the Saskatchewan, Churchill and Nelson rivers and in Cumberland Lake (Scott and Crossman 1973; Roberge, personal communication); and in Manitoba in lakes Winnipeg, Winnebago, Manitoba, Playgreen and Cross, and the Assiniboine and Red rivers (Scott and Crossman 1973; Roberge, personal communication). In Ontario, Lake Sturgeon have been reported from the Great Lakes basin and the drainage of Hudson Bay. They extend east in the St. Lawrence to St. Roch des Aulnaies, beyond which salinity levels are apparently too high for the species (Harkness and Dymond 1961). In Quebec, Lake Sturgeon have been observed in most of the rivers of the James Bay basin (Rupert,

Eastmain, Grand and Broadback rivers), and the large rivers draining into the St. Lawrence west of the salt water termination (Magnin 1963; Nadeau, personal communication).

Protection

Lake Sturgeon are protected and managed in Canada under the Fisheries Act by each province in whose jurisdiction they occur. Similar legislation exists in the USA to protect stocks in the eastern states. The species had been listed by the Convention for International Trade in Endangered Species of Wild Fauna and Flora (CITES) under Appendix II, but was delisted in 1983, as Canada and the United States both agreed that the species was not endangered.

Alberta, Saskatchewan, Manitoba, Ontario and Quebec fishery regulations (under the Federal Fisheries Act) control commercial and recreational fisheries for the Lake Sturgeon through open and closed seasons, size limits, catch and possession limits, and means of capture (net mesh sizes, etc.). Regulations vary from province to province and year to year; current regulations may be obtained by contacting respective provincial fisheries agencies. Previous and recent management efforts have frequently failed to sustain yields although they have often kept stocks from extirpation.

Population Sizes and Trends

Population estimates of Lake Sturgeon are largely unavailable, but the history of the fishery and commercial catch data demonstrate the drastic effects of the fishery on the species. The early fishery in Canada is not as well documented as that of the United States, but the results have always been the same — a high initial yield followed by a sharp decline to low levels. The fish are now nowhere as abundant as formerly and may even not be common in some parts of the historic range. Yet, in most areas, populations

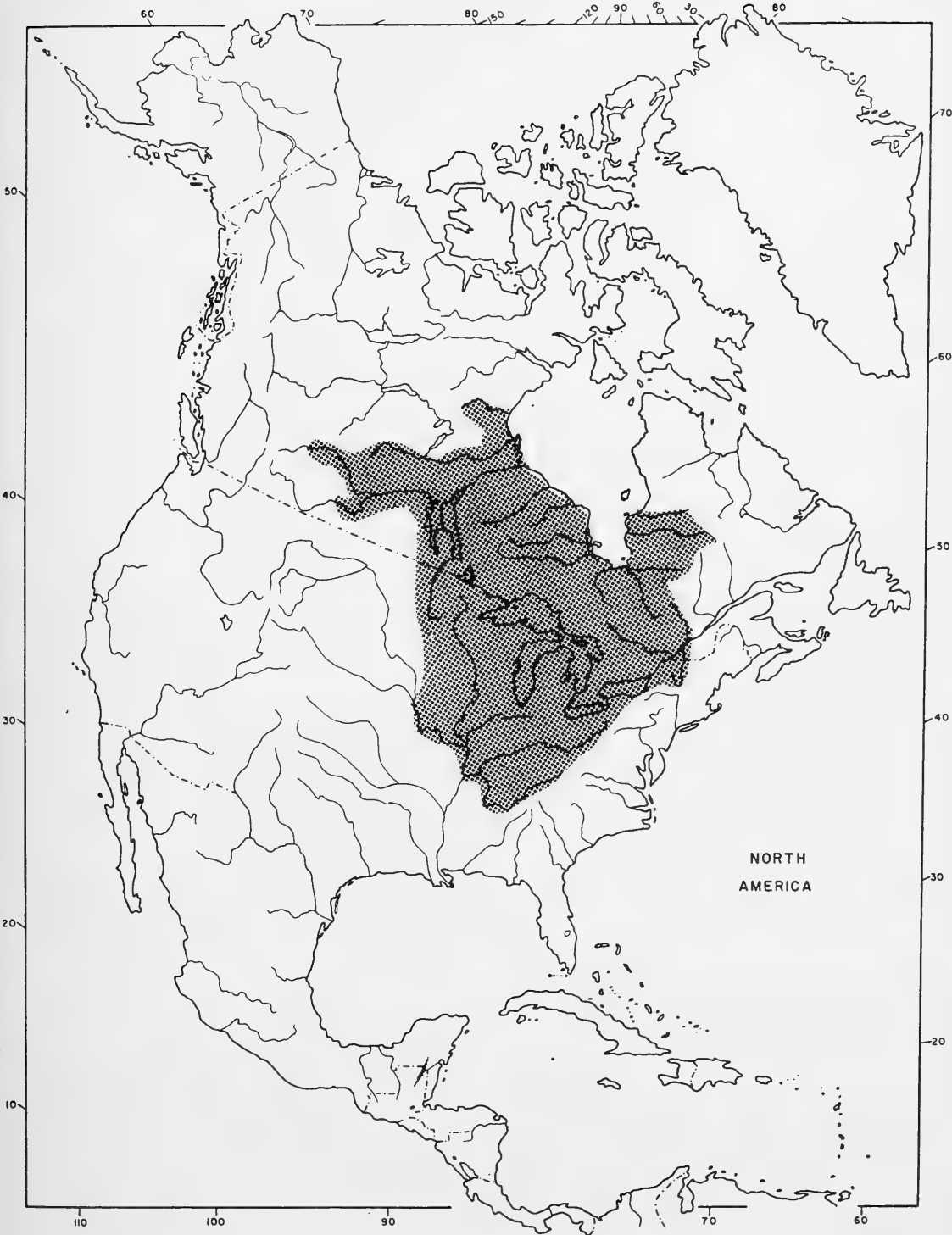


FIGURE 2. North American distribution of the Lake Sturgeon.

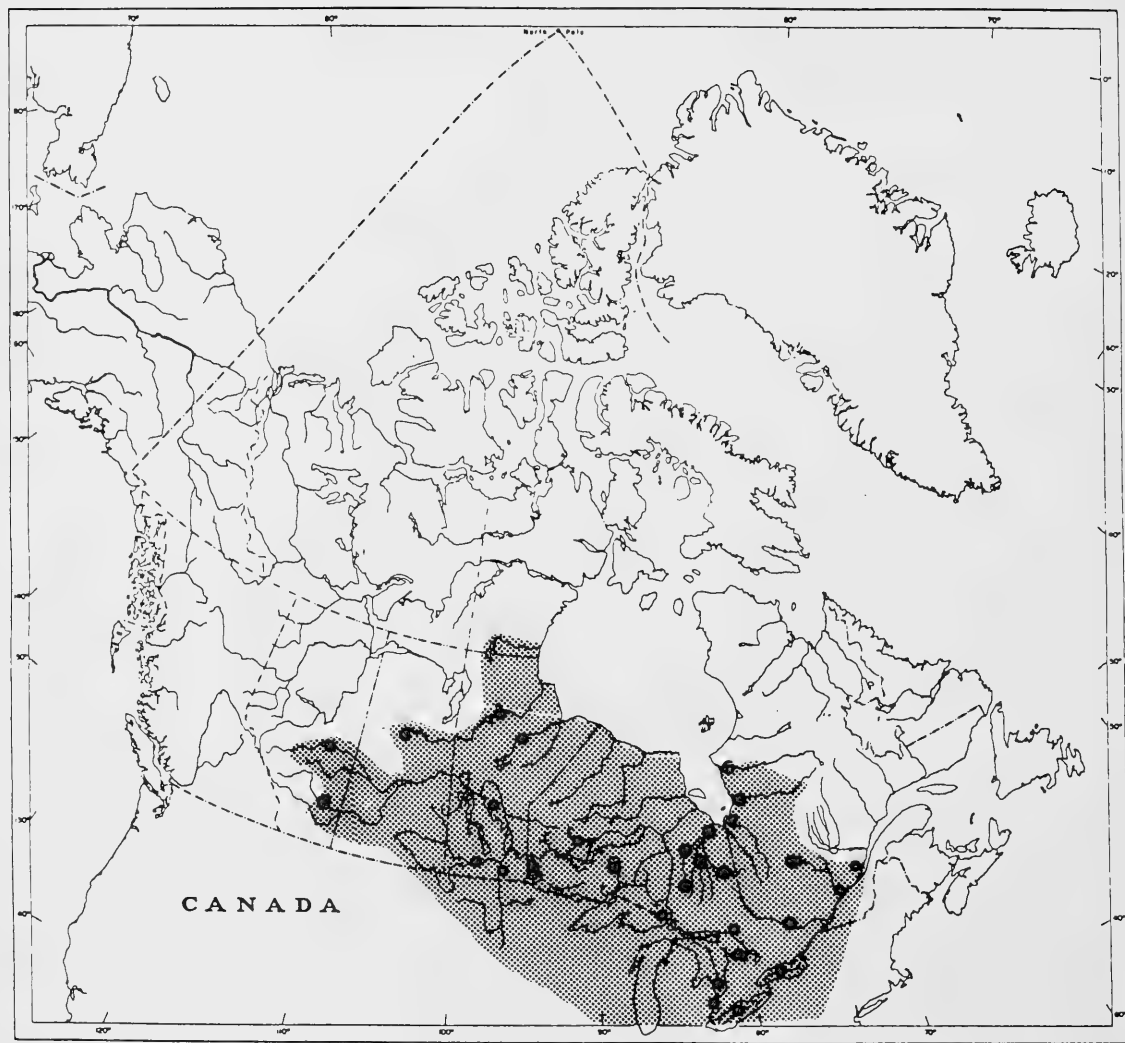


FIGURE 3. Canadian distribution of the Lake Sturgeon indicating general locations of fisheries (past or present).

are sufficient to provide a modest managed fishery under close regulation.

The North American sturgeon fishery dates back into the last century when Lake Sturgeon were a highly prized and important staple in the diet of native people before the advent of the Europeans. Prior to the 1860s, sturgeon were not actively sought commercially. In 1860, the significant commercial fishery began with the opening of a market for smoked fish in Sandusky, Ohio (Smith and Snell 1891; Harkness and Dymond 1961), and by 1885 half of the fish marketed were sturgeon. In Ontario, the value of the sturgeon was not fully appreciated and most of the

fish taken in Canadian waters were shipped to the United States (Wright 1892).

The bulk of this early fishery was in the Great Lakes; by 1885 the Lake Erie catch alone was over 2.3 million kg. Scott and Crossman (1973) have indicated that the usual weight of Lake Sturgeon from current commercial fisheries varies from 4.5 to 36.3 kg [Alberta - historically 14-22 kg (Roberge, personal communication), now 6.8 kg (Bishop 1983); 20 kg in Manitoba (Lord 1984); 5.5 to 31.8 kg in Saskatchewan, reflecting maximum and minimum weight regulations (Roberge, personal communication); Quebec, 10-15 kg (Mongeau et al. 1982); and 5.1 kg

(Moose River) or more in Ontario (Threader and Brousseau 1983)]. Threader and Brousseau (1983) have shown that fishing mortality of 20% will surpass the sustained yield of Lake Sturgeon in the Moose River of Ontario, and Semakula and Larkin (1968) have shown a similar situation for the White Sturgeon (*A. transmontanus*) fishery on the west coast. With this evidence in hand, and taking into account available catch statistics for the early fisheries (Rousso 1955; Harkness and Dymond 1961), Lake Sturgeon populations of the Great Lakes prior to 1880 probably numbered in the hundreds of thousands, and perhaps in thousands or tens of thousands in the inland lake and river systems of Alberta, Saskatchewan, Ontario and Quebec.

An alarming factor in sturgeon fisheries was, and is, the rapid decline in yield accompanying harvest. Although the rate and extent of the decline varies from region to region, when demonstrated graphically (see Harkness and Dymond 1961) the results are remarkably similar — a relatively high initial yield, with a sudden and permanent decline to relatively low levels. Although the reasons for this reaction of sturgeon populations to fishing pressure and the failure to sustain higher yields are not well understood, they are in part tied to several aspects of the life history and will be discussed later.

For example, sturgeon catches in Lake Erie suffered an 80% decline in 10 years (1885-1895), in Lake Huron 56%, in Lake of the Woods 90% over seven years (1893-1900), and by the turn of the century catches were only a small fraction of the initial yield (Harkness and Dymond 1961). The total annual catch in Ontario has never been above 90 tonnes since 1925 (Scott and Crossman 1973) and since 1980 has averaged 40 tonnes [Department of Fisheries and Oceans (DFO) 1984]. Total Ontario production from the 1920s onwards has averaged 2-3% of maximum production of the 1880s.

In Ontario, as mentioned previously, the early fishery was largely confined to the Great Lakes, but other areas such as the St. Lawrence, Ottawa, Madawaska and Bonnechere rivers, lakes in Lanark and Renfrew counties, lakes Simcoe and Couchiching (where the species is now either extirpated or very rare), and Lake of the Woods were also utilized in the 1880s (Harkness and Dymond 1961). By 1895, production in the Great Lakes had started to decline, and the Lake of the Woods fishery was supporting 39% of the Ontario catch. But by 1900, production here had dropped to 11% of the 1893 peak, and by 1957 catches were only 0.005% of the 1893 maximum (Scott and Crossman 1973). The total Ontario production was further supported through the opening of fisheries in Lake Nipissing (1900) and Lake

Nipigon (1917) with the same results — high yields from the virgin populations followed by a rapid decline. Lake Nipigon and Lake of the Woods fisheries were virtually non-existent by 1935, but the Lake Nipissing fishery has managed to maintain a sustained yield of 4000-5000 kg annually (Harkness and Dymond 1961; DFO 1984).

As the major, easily accessible, sources of sturgeon were overfished, attention turned to waters in northwestern parts of the province, and by 1945, northern Ontario production accounted for 12% of the total. Production in these virgin waters followed the course seen elsewhere and production soon shrank to relative insignificance but northern waters still yield 40% or more of Ontario's total production (Harkness and Dymond 1961).

Ontario is now nearly depleted of virgin sturgeon waters and harvest will continue to be in the order of 10-15 tonnes per annum. Very little information exists on present sturgeon abundance in the province; however, several studies are currently being undertaken or are planned by the Ontario Ministry of Natural Resources (OMNR). Threader and Brousseau (1983) have indicated a population of 7088 fish in the Moose River and estimated an annual sustainable yield of 400 kg for this population. Similar populations appear to exist in the Ottawa River, where the quota for the fishery has been set at 500 kg (Tilt, personal communication), and in the rivers of Cochrane and Geraldton districts (e.g. Albany, Ogo, Kenogami) with a total quota of 1400 kg. Until the results of the OMNR studies are available, little more can be said of present Ontario populations except that they are only a small percentage of the populations existing before the commercial fisheries were opened. The Northern Region (OMNR) sponsored a Sturgeon Workshop at Timmins in February of 1986, and the proceedings will appear in a special edition of the OMNR Fisheries Technical Series. Notwithstanding, the populations of each of the river systems which support sturgeon probably number in the low thousands, and in the Great Lakes, tens of thousands.

In the prairie provinces, fishing for sturgeon was minimal prior to 1895, mainly because of lack of transportation to available markets. By 1890, after the advent of the railroad, interest in sturgeon had increased. Commercial fishing in Manitoba commenced in Lake Winnipeg and its tributaries (Red and Assiniboine rivers) and the following account has been provided by Roberge (personal communication) from DFO and provincial records. The Lake Winnipeg fishery (Red and Assiniboine rivers) peaked in 1900, with a catch of over 445 990 kg. It continued at a high level over the next four years, then diminished to 13 636 kg in 1910 when the fishery was

closed. It remained closed until 1916, when approximately 52 700 kg were landed. Over the next eleven years, landings fluctuated until 1928, when the fishery was again closed.

With the decrease in landings for Lake Winnipeg, even though effort was increased, other areas were then sought for commercial fishing. In 1907, commercial fishing for Lake Sturgeon on the Nelson River began. Catches were low until 1917, when 68 182 kg of sturgeon were landed. An additional 30 910 kg were taken the following year. Fishing dropped off until 1930 when the river was closed but in 1937 fishing was resumed and remained open due to the war. In 1945 the river was again closed until 1953.

Another area chosen for Lake Sturgeon commercial fishing in Manitoba was the Churchill River. Here fishing began in 1924, but the river was closed between 1926 and 1938. It was reopened and remained open, also due to the war, until 1945, and then was closed in 1946, until it was reopened along with the Nelson River in 1953.

Commercial fishing for Lake Sturgeon in Manitoba yielded approximately 11 273 and 13 636 kg in 1953 and 1954, respectively. After this, the yield dropped off until commercial fishing for sturgeon was closed in 1961. It resumed again and has been continuing since 1970. Landings have fluctuated from 2-7 tonnes annually and appear to be on another downturn as indicated by the commercial catches.

As in Ontario, it would appear that sturgeon populations in Manitoba have been seriously depleted by intensive fisheries. Where populations may previously have been in the tens of thousands in Lake Winnipeg, they are now seriously reduced to the low thousands (Fitzjohn, personal communication) or less (Sopuck 1981; Lord 1984). Elsewhere, the populations appear to be healthy (Fitzjohn, personal communication) and not in any danger. In fact, a four year tagging study now being undertaken on the Winnipeg River (Fitzjohn, personal communication; Lord 1984) has indicated the presence of sizeable populations (population size unknown as yet, but over 800 individuals have been tagged to date). However, the study area is a reservoir that prohibits movements to other areas where stocks may be somewhat depleted. The commercial fishery in Manitoba is managed for low production (20 tonnes) and no increase in harvest. Current regulations permit a marketable quota of 20 tonnes but commercial harvests are in the area of 7 tonnes (DFO 1984). It may be that current fisheries are over-fishing available stocks but without further studies to assess stock size, this is not yet verifiable.

Lake Sturgeon have been commercially fished in Saskatchewan since 1900. The South Saskatchewan

River, historically, has produced 75% of landings (Roberge, personal communication). Fisheries have also existed in the Churchill River system, including Cumberland and Namew lakes. Peak production, an approximate annual average of 10 000 kg, was reached between 1933 and 1942. From 1943 to 1950 production decreased significantly. It increased slightly from 1951-1959 but was less than 5000 kg before declining again until 1969 when the fishery was closed due to high mercury levels in the fish (Roberge, personal communication). In 1973, the fishery was again opened in Cumberland Lake and the Churchill River with quotas of 3200 and 5400 kg, respectively, but production has averaged between 2700 and 3600 kg annually (Roberge, personal communication).

Thus, it would appear that Lake Sturgeon populations in Saskatchewan, mainly in the Churchill and South Saskatchewan rivers, were never overly large (probably numbering in the low thousands) and are now much lower in numbers (Haugen 1969). They may in fact be over-exploited, but here again, further study is required before any estimate of effects of the fishery on stock size can be determined.

Little information is available on the commercial fishery in Alberta prior to 1940, but the average weight was 14-27 kg (Roberge, personal communication). The fishery was closed in 1940 because of the possibility that the Lake Sturgeon was an endangered species. The province reopened sturgeon fishing to anglers in 1968 under a strict management regime (Bishop, personal communication). This fishery has developed primarily into a sport fishery, and most of the fish caught are returned alive to the water. The number of fish taken has increased annually from 56 in 1968-69 to 614 in 1982-83, but the actual harvest (fish not returned) has only increased from 38 to 181 over the same period (Bishop 1983). Alberta stocks of Lake Sturgeon may not now be that much different from historic levels and appear to be healthy, but until the results of current population studies are known, little more can be said (Bishop, personal communication). It does not appear to be feasible to establish a commercial fishery in Alberta and current restraints on the sport fishery would appear to ensure the survival of these populations.

Records of the sturgeon fishery in Quebec are not complete prior to 1964, although active fisheries had been operating in some regions, principally in the St. Lawrence near Montreal, lakes St. Pierre, St. Louis and St. François, the Lake of Two Montains, and the Richelieu, Assumption and St. François rivers (Mongeau et al. 1982). Dymond (1939) gave some interesting data on Quebec, Ottawa River, basic catches which documented a decline from 28 840 kg in 1898 to a low of 6500 kg by 1907.

Native fisheries have been important in larger rivers such as the Fort George, Nottaway and Waswanipi. Mongeau et al. (1982) have indicated that the situation in Quebec was similar to that elsewhere in Canada — a period of high yield from virgin stocks followed by a rapid decline in catches. For example, in Lake St. François catches fell from 8700 kg in 1964 to 1600 kg by 1969; similarly, in Lake St. Louis the annual catch decreased from 39 750 kg in 1972 to 15 360 kg in 1976 (Mongeau et al. 1982).

Lake Sturgeon are still found in some numbers in the St. Lawrence and the major rivers draining into it, such as the Richelieu, Assumption and St. François (Mongeau et al. 1974), as well as lakes François, St. Pierre and St. Louis and Lake of Two Mountains. For the most part there are still many small populations (Mongeau et al. 1982). Although specific studies are required, there appears to be a shortage of adults 15 to 50 kg or more in size. The fishery now averages 73 tonnes annually, which is a decline from the 1972-1976 average of 92 tonnes (Mongeau et al. 1982; DFO 1984). The Quebec fishery is a fairly recent one compared to those elsewhere, and the high production may not be capable of such a sustained yield. In addition, the landed values also include Atlantic Sturgeon, *A. oxyrinchus*, which may account for 25-30 tonnes of the annual catch (Vladykov and Greely 1963). Also, the number of larger individuals caught (30-50 kg) which were common in the 1960s and early 1970s are now rare. The average weight is 12 kg, with most fish in the 2 kg size range (Mongeau et al. 1982).

The Lake of Two Mountains presents an interesting case since virtually all fish, including sturgeon, were annihilated from the area in the 1950s through chronic oxygen depletion brought about by waste disposal from the pulp and paper industry (Le Sauter 1967; Mongeau and Massé 1976). Since 1964, following rectification of the situation, most species have returned to nearly normal abundance. However, certain species, such as the sturgeon, have not as yet reached former population levels (Mongeau et al. 1982) and the bulk of the population consists of smaller individuals aged 10-14 years although several thousand sub-adults are present. By 1978, the population distribution and age class structure appeared to be normal (Mongeau et al. 1982), although it may take up to 40 years for the population to return to pre-1950s structure. Recruitment at present would appear to be from a migration of mature individuals from other parts of the river (Mongeau et al. 1982).

The northern Quebec populations are heavily harvested by the Cree Indians who remove some 2300 sturgeon annually, mainly from the Fort George and Waswanipi rivers (Boulva, personal communication).

Although some detailed biological studies of the Lake Sturgeon in northern Quebec have been carried out (Magnin 1964, 1966a,b, 1980), these have not addressed population estimates needed to determine management regimes (Boulva, personal communication). However, it appears that the Cree harvest is at or near the sustainable yield.

In addition to the native harvest, a small commercial harvest has been conducted intermittently in the inland rivers and lakes of the Abitibi-Temiscaming area of Quebec since 1945 and produces an average yield of a few hundred kilograms annually (Nadeau, personal communication). Lake Sturgeon is the principal species in the interior fishery in the area and there has been some indication of an increased effort in the region even though populations are thought to be declining.

The Lake Sturgeon still occupies most of its historic Canadian range, although abundance of stocks in most areas is well below that prior to the establishment of commercial or sport fisheries. It is apparent that population estimates are needed on as many stocks as possible before a clear picture of actual abundance can be determined. Catch records reveal declines in populations and most fisheries today may be being maintained at or near sustainable yields. Although it is apparent that Lake Sturgeon are still widespread in Canada, it is also clear that without careful management the situation would be quickly changed. Lake Sturgeon numbers may be slowly declining over the entire range, although they are not near the status of rare or threatened.

Habitat

Lake Sturgeon are shallow-water fish, usually inhabiting waters from 4 to 9 m in depth, but larger fish have been taken at depths of up to 43 m (Harkness and Dymond 1961; Scott and Crossman 1973). These fish are usually confined to freshwater but have been taken in brackish water in the St. Lawrence River and in the Moose River near James Bay (Scott and Crossman 1973). The usual habitat, the highly productive shoal areas of larger lakes and rivers, is related to anatomical features and feeding habits which have evolved to confine these fish to a diet of bottom living organisms which are most abundant in these areas (Adamstone 1924). Sturgeon are usually not competitive with other bottom feeders, such as the Lake Whitefish (*Coregonus clupeaformis*), White Sucker (*Catostomus commersoni*) or Longnose Sucker (*C. catostomus*) which utilize the same food source, since they feed in different areas (Scott and Crossman 1973).

Lake Sturgeon spawn in areas of swift waters or rapids at depths of 0.6 to 4.7 m, often near low

waterfalls which prevent upstream migration (Harkness and Dymond 1961; Scott and Crossman 1973). In lakes where suitable spawning rivers are not readily available they spawn over rocky ledges or islands where wave action produces the level of oxygenation required for the eggs. As the eggs are scattered, these rocky areas of rapids or shoals minimize egg losses to predation and other factors.

Most sturgeon have been found over mud bottoms. They are often taken in areas of gravel and mud but may be found over any bottom which supports their forage base (Harkness and Dymond 1961). Younger fish may stay in the river or shallower waters during their first one or two years of life (Harkness and Dymond 1961) and older fish are usually found in deep waters. There may be some temperature or oxygen dependency, as the fish usually move away from shallower waters in the summer and return in the fall (Harkness and Dymond 1961; Scott and Crossman 1973). This may also be related to forage species as seasonal movements are not well understood (Scott and Crossman 1973). However, they are not usually found in waters above 23.8°C (Ono et al. 1983). Lake Sturgeon are not usually found in geographical areas of a sedimentary nature, perhaps because of a lack of suitable spawning areas (Harkness and Dymond 1961).

Biology

Precise information on where and when sturgeon spawn throughout the range is not available, and there is considerable variation with latitude and other factors affecting temperature (Harkness and Dymond 1961; Priegel and Wirth 1971). Lake Sturgeon spawn in the spring from May to late June when the spawning rivers are free of ice, although they have been observed to move under ice (Scott and Crossman 1973). Spawning does not commence until water temperatures have reached 13°C and is inhibited if the temperature falls below that level or surpasses 21°C (Harkness 1923; Harkness and Dymond 1961).

Migration movements are usually not extensive, but sturgeon may move up to 176-530 km to find suitable habitat or until stopped by falls or impoundments (Harkness and Dymond 1961; Priegel and Wirth 1971; Scott and Crossman 1973). Migration is differential, with males reaching the spawning area first. The fish congregate until appropriate temperatures are reached (Scott and Crossman 1973). Females are in spawning condition for a brief period of time, but may not release all of the eggs in one spawning act, and may spawn over a period of one or more days (Harkness and Dymond 1961). During spawning, they lie together in groups of two or three, one or two males to each female. The

male swims higher than the female so that the milt is released over the eggs as they are extruded (Harkness and Dymond 1961). The adhesive eggs are shed and scattered by the current to adhere to rocks and logs. Ripe eggs are black and 2.7-3.5 mm in diameter (Roussow 1957). Egg number varies with the age and size of females, usually increasing with age and size, but is also variable in fish of approximately the same weight. Cuerrier (1949) [as cited by Scott and Crossman (1973)] gave calculated minimum and maximum numbers of eggs as 107 570 - 885 360; these figures can be extrapolated to indicate that 90.9 kg females could carry up to 3 000 000 eggs.

At incubation temperatures of 15.6-17.8°C the eggs hatch in five to eight days and the young fish, which are approximately 8 mm in length, are nourished by the yolk sac for 9 to 18 days (Scott and Crossman 1973). Within 16 days the fins are well developed and the young fish at 21 mm are minatures of the adults as they begin to feed. They grow rapidly in the first summer (199+ mm), but growth is somewhat slower after the first year of life. Harkness (1923) and Harkness and Dymond (1961) have shown that in the first five years there is a rapid increase in length but little in weight. This relationship reverses from 5 to 15 years as the fish grow older, and becomes pronounced after 20 years or so when sexual maturity is reached.

Growth varies considerably and the variation differs within the same river system as well as between sturgeons of different waters (Priegel and Wirth 1971). This variation depends on several factors, including water temperatures and amount of available food but fish from larger, warmer bodies of water to the south generally demonstrate faster growth rates than those farther north (Figure 4). Tables or graphs of comparative age/length (or weight) relationships are of limited value for this species, as it is difficult to accurately age older fish to within five to six years (Scott and Crossman 1973). However, graphic representations, such as those of Figure 4, do not serve to show the variability in growth in different environments. Sturgeon may be as long as 130 cm at approximately 20 years of age in Lake Huron or Lake Winnebago but will not attain this length before 36 years of age in Lake Nipigon (Harkness and Dymond 1961). Magnin (1977) has reported that fish in the La Grande River of northern Quebec may be 70-110 cm at 20 years, and 125-144 cm at 40 years, with weights of 3.5-8 kg and 6-26 kg, respectively. Similar-aged fish in lakes Huron and Winnebago may weigh 8-10 kg and 20-25 kg, respectively.

Of all freshwater fish, the sturgeon takes the longest to reach sexual maturity. The age of first spawning for Lake Sturgeon is different in the two sexes and varies with location from north to south. Roussow (1957)

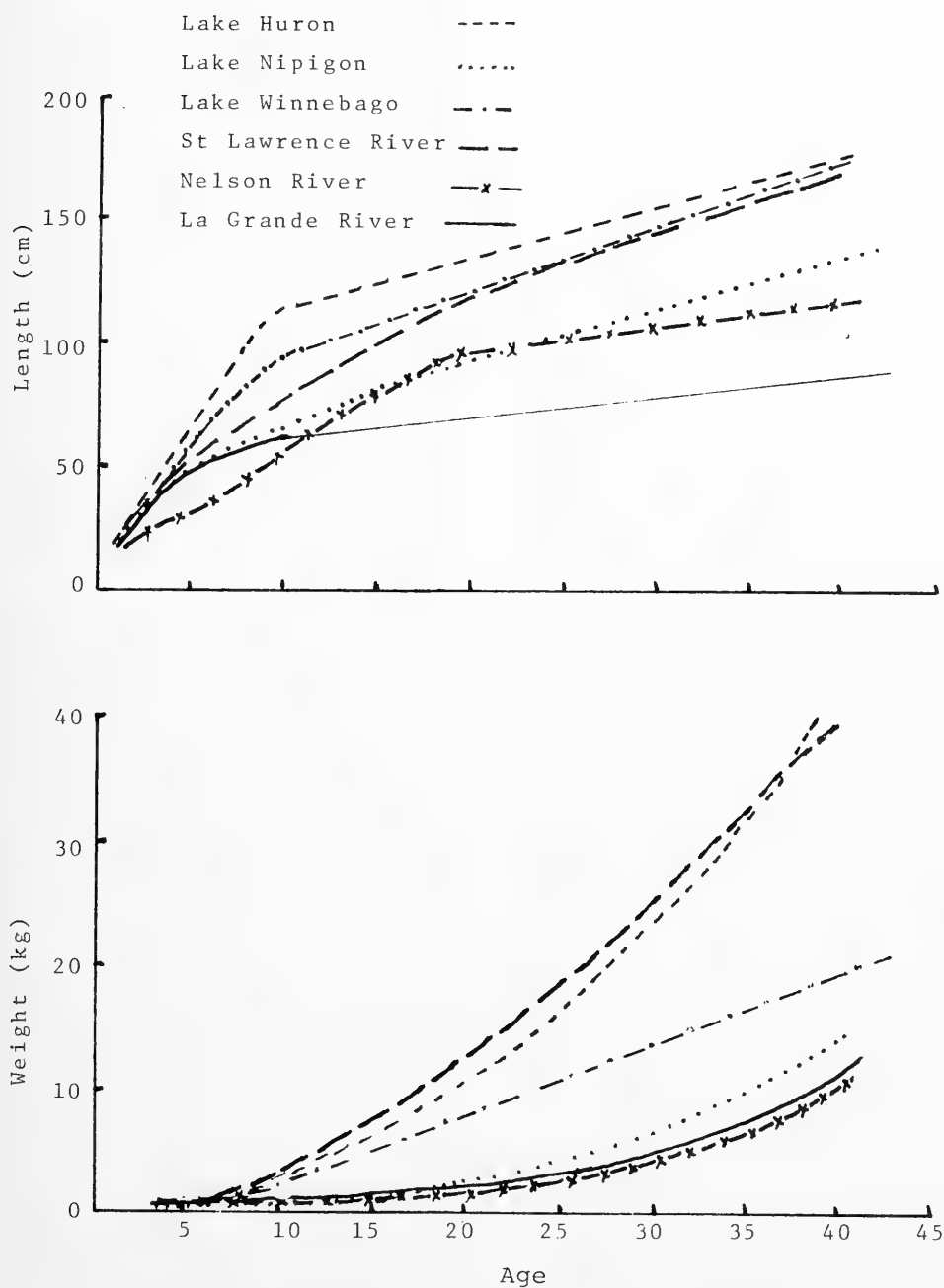


FIGURE 4. Comparative growth rates of Lake Sturgeon in lakes Huron, Nipigon, and Winnebago and the St. Lawrence, Nelson and La Grande rivers. The curves were calculated from data presented by Harkness and Dymond (1961), Priegel and Wirth (1971) and Magnin (1977).

indicated that maturity was reached at 8 to 13 years, but that first spawning took place at 8 to 19 years for males, and 14 to 23 years for females. Ages at first spawning for several populations are given in Table 1, showing the variation depending on locality. As in most species, not all individuals within a population will spawn for the first time at the same age. It is evident that for this large, slow-growing species maturity is late. In addition, after reaching sexual maturity the fish do not spawn each year thereafter. Magnin (1960b) has shown that the interval between successive spawnings may increase with age, and may be four to six years in females, and two to three years in males. This varies somewhat with locality from north to south.

The Lake Sturgeon is perhaps one of the longest lived freshwater fish, and age determinations from otoliths, opercula, and pectoral ray sections are not easy or uniform due to life span and environmental variability (Scott and Crossman 1973). It is almost impossible to accurately age older fish within five to six years. Females appear to live longer than males (Scott and Crossman 1973) and this may be the reason for disparate sex ratios in older fish. Sex ratios are nearly equal at birth (Harkness and Dymond 1961). Priegel and Wirth (1971) felt that males may be more prone to natural mortality on spawning runs or more apt to be taken by fishermen due to their smaller size. The usual maximum age for males has been given as 55 years, and that for females as 80 years (Magnin 1966a). Some sturgeon live longer than this, and the record is a 154-year-old specimen taken in Lake of the Woods in 1953 weighing 94.6 kg (MacKay 1963). Most sturgeon taken today measure 91.5-142.5 cm in total length and weigh 4.5 to 36.3 kg, although larger specimens are occasionally seen.

Although seasonal movements other than spawning migrations are not well known, within their home areas Lake Sturgeon travel widely in loose aggregations. Within the home range they move to deeper waters when the shallower waters warm in summer and then return in the fall as these waters cool, returning to moderate depths in winter (Scott

and Crossman 1973). They leave the home basin only at spawning time and return after spawning. Strong homing tendencies have been described, but there are records of fish moving to other areas (Priegel and Wirth 1971).

The sturgeons are large fish that feed almost exclusively on very small organisms that they suck up from the bottom. Food is searched by constant movement and the use of the sensory barbels. Virtually anything edible will be consumed, while nonedible materials are passed out the gill opening or the mouth. The fish have been found to feed throughout the winter (Priegel and Wirth 1971), and feeding habits differ according to food availability. Leeches, snails, small clams and other invertebrates are often consumed; insect larvae may form a large part of the diet. Small fish such as sticklebacks or sculpins have been found in stomach contents (Harkness 1923). Small fish may be an important dietary source in some areas: anglers report that sturgeon will respond to fish or bits of fish (Priegel and Wirth 1971). Vladykov and Greely (1963) found that up to 24% of the stomach contents of Lake Sturgeon in the St. Lawrence River could consist of small fish. Algae may be eaten at times, and sturgeon caught near grain elevators have stomachs filled with grain (Scott and Crossman 1973). A complete summary of food and feeding habits may be found in Harkness (1923) and Harkness and Dymond (1961). They apparently cease feeding during spawning.

The Lake Sturgeon is usually close to the bottom of the pyramid of animal numbers (i.e. trophic feeding level) and is usually associated with other bottom feeders such as the White Sucker with which it competes at some stage of its life cycle. Several other species of fish spawn in or near similar places as the sturgeon; however, direct competition is avoided by differences in timing and location of the actual spawning and feeding of the various species (Priegel and Wirth 1971). Predation (aside from that by man) is limited by the scutes of the young and size of the adults. Lampreys, *Petromyzon marinus* and *Ichthyomyzon unicuspis*, have been known to attach

TABLE 1. Approximate age and size at which sturgeon become sexually mature in different areas.

Age (year)		Average Length (cm)		Locality	Reference
Males	Females	Males	Females		
22		95.3		Lake Nipigon, Ontario	Harkness (1923)
19-20	26	76.2	83.8	Ottawa River, Ontario	Dubreuil and Cuerrier (1950)
12-19	14-23	76.2	116.8	Southern Quebec	Roussow (1957)
14-16	24-26	114.3	139.7	Lake Winnebago, Wisconsin	Priegel and Wirth (1971)
15-20	25-33	97.8	113.1	Nelson River, Manitoba	Sunde (1959)
18-20	20-23	85.7		Northern Quebec	Magnin (1966a)

themselves to Lake Sturgeon (Priegel and Wirth 1971) and may seriously weaken or kill them (Scott and Crossman 1973). Comparatively few other parasites have been recorded (Hoffman 1967) and there is no information as to whether these seriously affect the fish.

Limiting Factors

Natural mortality is not very likely to be a major factor after the first year of life in this long-lived species. Commercial exploitation has been one of the major factors limiting sturgeon populations. The effect of overfishing a virgin stock is the removal of a large percentage of the larger individuals. As the fishery becomes established the bulk of the surviving population are younger and less mature fish. In order to maintain fishing catches, intensity is increased with a corresponding increase in the harvest of younger and smaller fish. As the harvest surpasses the recruitment rate, more younger and smaller fish will be taken each season until the fishery collapses or is discontinued. As indicated previously, the above phenomenon was witnessed in virtually every sturgeon fishery.

Another factor limiting Lake Sturgeon populations is the construction of dams and barriers on large rivers which prevent migration to suitable spawning habitats (Priegel and Wirth 1971). The construction of dams to power grist mills, saw mills, etc., may have had an early effect on Lake Sturgeon and may have been a major factor in their decline in Lake Ontario (Harkness and Dymond 1961). The effect of a dam may be more subtle than mere prohibition of upstream migration; recent dams designed to manipulate river flow may result in spawning habitat disruption and destruction. Similar reductions in available habitat due to dam construction have been noted for other sturgeons (Parks 1978).

Pollution, habitat degradation, and related environmental stress produced by aquatic contaminants resulting from industrial, urban and rural development have undoubtedly also had their effects on sturgeon. Harkness and Dymond (1961) have recorded the effects of pulp and paper mill effluents on spawning habitat and sturgeon populations. Mongeau et al. (1974), Mongeau and Masse (1976), and Mongeau et al. (1982) have detailed the effects of the paper industry on the fishes of the lower Ottawa and St. Lawrence rivers where paper mill effluents (also high in PCBs and mercury) were responsible for massive die-offs of virtually all species in the Lake of Two Mountains in the early 1950s as a result of O_2 depletion. Since that time, the sources of industrial pollution which were responsible have been curtailed and fish populations in the area have returned to

almost pre-catastrophic levels (Mongeau et al. 1982). High mercury levels have also been reported in fish in Quebec waters (Delisle 1978) and in northern Ontario (Threader and Brousseau 1983). Graham (1982) has demonstrated the negative effects of dams and poor water quality from mining operations leading to the decline of White Sturgeon in Montana through an impact on food supply and reproduction. Disturbance of the fish during spawning has also been shown to interrupt reproductive success (Harkness and Dymond 1961).

Predation is not likely to be a major limiting factor of this species as the scutes protect the young and size protects the older fish. Lamprey have been reported to attack Lake Sturgeon (Priegel and Wirth 1971; Scott and Crossman 1973) and may severely weaken or kill larger fish. Comparatively few parasites attach themselves to these fish and the effect of those known to be associated with Lake Sturgeon has not been determined (Harkness and Dymond 1961).

The reasons for the failure of sturgeon to maintain higher population levels are not fully understood, but are most likely a synergistic product of life history factors, exploitation and environmental change. Lake Sturgeon are slow-growing fish and require 10 to 25 years to attain commercial size and anywhere from 12 to 33 years to reach sexual maturity (Harkness and Dymond 1961). Added to these factors is the infrequency of spawning which may vary from four to seven years. Population declines resulting from heavy exploitation as described previously might be expected to be reversed if the fishery were to be closed for a number of years. This has generally not been the case. Ten-year closures of the Lake Nipissing and Manitoba fishery did not increase commercial production nor did a 21-year closure in Lake Michigan (Harkness and Dymond 1961); however, Lake Michigan populations did increase. A four-year closure of the Nelson River fishery did increase productivity, but river conditions had not changed significantly. It would appear that a closure will not be beneficial in waters that have suffered environmental change. Spawning habitat and water quality would seem to be as important as life history factors in limiting the species. Any management undertaken to prevent over exploitation, whether it be complete closure, size limitations, or regulation of catch and season, will probably not be successful if water and other habitat conditions do not remain favourable. The State of Wisconsin has managed to sustain a viable sport fishery through a combination of regulatory procedures (length of season, size limits, catch limits, gear restrictions and licensing of anglers) which seem to have insured population stability (Priegel and Wirth 1971).

Although fishing may not remove all fish or reduce spawning populations below the number required to produce enough young to replenish the population (Beverton and Holt 1957), the exposure of the population in the spawning areas is a serious problem. The loss or degradation of spawning habitat is also critical — thus, the maintenance of suitable habitat is a crucial factor for the species.

Special Significance of the Species

The sturgeons are primitive fishes, relics of the Devonian period (300 million years ago) which have retained cartilaginous skeletal systems and a shark-like caudal fin. These fish have had a rather long and intimate association with man throughout history. Sturgeon were gourmet items at banquets in ancient Rome and this "King of Fishes" was considered the "Fish of Kings" in Britain during the middle ages (Ono et al. 1983). The Lake Sturgeon is the largest of the Canadian freshwater fishes and has had a somewhat sordid and varied history in this country.

Lake Sturgeon were at one time scorned by fishermen as a nuisance fish that destroyed gear. Prior to 1860, they were taken as an incidental species considered worthless and were killed and thrown back, used as feed for livestock and as fertilizer, or dried and used as firewood (Scott and Crossman 1973). They were, however, valued as a source of food by native peoples. After 1860, the worth of sturgeon flesh (smoked, dried or fresh) was realized and an intensive fishery commenced. It resulted in population reductions to levels from which some populations have never recovered. The commercial preparation of caviar and smoking of sturgeon began in 1855 and 1860, respectively, at Sandusky, Ohio. These were the principal reasons for the intensification of the fishery which was harvesting over a million kg in the Great Lakes before the turn of the century.

Overnight, the value of sturgeon increased from 25¢ per fish (regardless of size) to 12.5¢ per lb. compared with 10¢ for whitefish or trout (Harkness and Dymond 1961). Sturgeon were boiled for oil (used as a base for paint) which brought 75¢ per gallon, smoked, or sold fresh. The skin was tanned for leather and the swim bladder was used in the production of isinglass (used as a clarifying agent in the wine and beer industries, in the manufacture of glue, to size and stiffen textiles, as a setting agent in the production of jams and jellies, and as a water-proofing agent). From 1888 to 1902, this production brought \$1.00/lb. (10 fish). After 1902, the demand disappeared when carrageenan and other seaweed derivatives replaced isinglass (Harkness and Dymond 1961). The eggs (caviar), once fed to pigs, became the food of epicures and much of the sturgeon's reputation as a valuable

fish was due more to the influence of caviar than to the price of the flesh (Harkness and Dymond 1961). In 1885, caviar brought 10¢/lb and had increased to \$1.00/lb. by 1900 (Harkness and Dymond 1961).

Sturgeon production (yield) is now low in Canada. Since 1959 catches have fluctuated from a high of 88 472 kg in 1961 to a level of 38 965 kg in 1966 (Scott and Crossman 1973). Canadian production has increased over the ensuing period to a fairly stable catch of 88-92 tonnes annually since 1976 (DFO 1984), of which 40 tonnes are taken in Ontario and Manitoba, 3-4 tonnes in Saskatchewan and the remainder in Quebec. The estimated Alberta catch of 3-4 tonnes is purely a sport fishery and many fish are returned alive to the streams. The increase in production since the 1960s may not be directly related to population increases following years of strict management regimes but more probably reflects a combination of management and regulatory mechanisms (in particular quotas), the fishing of new populations, and an increased interest in sturgeon because of rising prices and the unavailability of Iranian caviar in the United States.

Wholesale values have fluctuated from 22-26.4¢/kg prior to 1925 to \$2.00/kg in 1952 (Scott and Crossman 1973). From 1962 to 1966 the price averaged \$2.00-3.00/kg, and since 1976 has risen to, and remained in, the \$6.00/kg range (Scott and Crossman 1973; DFO 1984). Caviar has demonstrated similar price trends with 1925 values of \$3.30/kg and a 1952 high of \$9.53/kg, declining to a 1962-1966 average of \$7.26-\$8.73/kg (Scott and Crossman 1973). Since 1976, prices have risen dramatically and in the 1980s Lake Sturgeon caviar has had a wholesale value of \$17.60-\$22.00/kg (Roger, personal communication). Smoked Lake Sturgeon and caviar are today epicurean treats that few can afford. The current price (1987) to the consumer for Canadian Lake Sturgeon caviar (judged by most to be second in quality only to Caspian Sea caviar derived from *Huso huso*) is \$250.00/kg and smoked sturgeon sells at \$39.90/kg.

The Lake Sturgeon is not an important sport fish in Canada (although the Alberta fishery is purely recreational) due to low population levels and limited distribution. Important sport fisheries exist in Michigan, Minnesota and Wisconsin, and the fish still provide an important source of nutrition to native populations. Sport fishing for sturgeon in northern Ontario is also becoming increasingly popular.

Evaluation

Lake Sturgeon are very widely distributed in Canada and, although populations are nowhere as abundant as they were prior to establishment of commercial fisheries, there is no indication that the

species is endangered. In fact, they are still fairly common in many northern areas (in particular the clay belt of Ontario and Quebec) and recent U.S. investigations led to the Convention on International Trade in Endangered Species (CITES) delisting of the species with Canada's agreement.

Certain stocks, such as those of Lake Ontario and Lake Winnipeg, were seriously depleted by commercial exploitation, but complete closure of the fishery in these areas has saved the remaining animals from extirpation and there is some indication that stocks in these areas may be in better shape than previously thought. Notwithstanding these factors, we still know very little about the relative abundance of these fish, and outside limited studies in Ontario, Manitoba and Quebec (as listed earlier), very little effort has been expended to derive further knowledge.

Since sturgeon flesh and caviar are in demand and return a high dollar value, commercial interest is liable to increase. The unavailability of other sources of caviar, such as Iran, to the New York market could introduce increased pressure on fisheries managers for greater quotas. Current management emphasis links available harvests to sustained yield. Therefore, it is of utmost importance to determine population sizes to prevent over-exploitation. Basing harvests on catch statistics for a species with a long lifespan, late maturity and rigid habitat requirements for spawning is not a sound management practice. In order to maintain a sustained yield, population sizes, as well as other factors of population dynamics (natural mortality, etc.) must be known and harvests must be regulated to prevent the taking of fish before they reach reproductive potential. Size limits alone have not proved practical in the regulation of sturgeon populations in Wisconsin (Priegel and Wirth 1971) and perhaps the best tool has been the combined use of restricted length and number of seasons.

Artificial propagation of Lake Sturgeon has been suggested as one means of improving recruitment (Harkness and Dymond 1961) but so far has not proven practical (Priegel and Wirth 1971), although the USSR has had some success with sturgeon (probably *Huso huso* and *H. dauricus*) in the Caspian Sea and Lake Paleostomi (Burchuladze and Zarkua 1979). Minnesota has introduced an apparently successful program which was a topic of discussion at the OMNR Sturgeon Workshop in February 1986.

Control of exploitation and habitat requirements are now the most important factors in maintaining the conditions necessary for the continued success of these fish in Canadian waters. Continued industrial development and urban sprawl may be the most serious threat facing Lake Sturgeon. Pollution can and is being reduced, but dams and other flood

control measures do irreparable damage to vital spawning habitat and when spawning habitat is not protected all other management efforts are for naught.

At the present time, Lake Sturgeon in Canada are not endangered or even rare. The threat of serious declines and extirpations looms large if necessary stock assessments and habitat protection measures are not forthcoming.

Acknowledgments

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Literature Cited

- Adamstone, F. B. 1924. The distribution and economic importance of the bottom fauna of Lake Nipigon. University of Toronto Studies, Publication of the Ontario Fisheries Research Laboratory.
- Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Her Majesty's Stationery Office, London.
- Bishop, F. G. 1983. The 1982 harvest of Lake Sturgeon (*Acipenser fulvescens*) from the South Saskatchewan River, Alberta. Alberta Energy and Natural Resources Fish and Wildlife Report, Edmonton.
- Burchuladze, O. G., and Z. G. Zarkua. 1979. Perspektivy razvitiya osetrovogo khozyajstva v yuso-vostochnoj chasti Chernoso morya. hi: Biologicheskie osnovy produktiv-

- nusti vodoemou Gruzinskoj ssr. *Edited by* N.M. Naumou. UNIRO: Moscow, USSR: 7-13.
- Cuerrier, J. P.** 1949. L'esturgeon de lac, -age-croissance-maturité. Chasse et Pêche 1: 26.
- Delisle, C. E.** 1978. La mercure dans les écosystèmes aquatiques de la Province du Québec, Canada. Verhandlungen Internationalen Verein Limnologen 20: 1947-1955.
- Department of Fisheries and Oceans.** 1984. Freshwater fisheries-catches and landed values by species 1981-82, 1982-83. Report of Fisheries and Oceans, Ottawa.
- Dubreuil, R., and J. P. Cuerrier.** 1950. Rapport sur l'étude du cycle de maturation des glandes génitales chez l'esturgeon de lac (*A. fulvescens* Raf.) de la rivière Ottawa, 1949. Québec. Ministère d'Industrie et Commerce et Conseil National de Recherches, Ottawa.
- Dymond, J. R.** 1939. The fishes of the Ottawa region. Contributions of the Royal Ontario Museum (Second edition) 15: 1-43.
- Graham, P.** 1981. Status of white sturgeon in the Kootenai River. Montana Department of Fisheries and Wildlife Report. Kalispell, Montana.
- Harkness, W. J. K.** 1923. The rate of growth and the food of the lake sturgeon (*Acipenser rubicundus*) (Le Sueur). University of Toronto Studies in Biology Series 24; Ontario Fisheries Research Laboratories, Toronto, Number 18: 13-42.
- Harkness, W. J. K., and J. R. Dymond.** 1961. The lake sturgeon: the history of its fishery and problems of conservation. Ontario Department of Lands and Forests, Fish and Wildlife Branch, Toronto.
- Haugen, G. N.** 1969. Life history, habitat and distribution of the Lake Sturgeon (*Acipenser fulvescens*) in the South Saskatchewan River, Alberta. Alberta Department of Lands, Forests, Fish and Wildlife Report, Edmonton, Alberta.
- Hoffman, G. L.** 1967. Parasites of North American freshwater fishes. University of California Press, Los Angeles, California.
- LeSauter, T.** 1967. Rapport sur l'état des eaux de la rivière Outaouais. Québec Ministère de la Santé, Service Génie Sanitaire, Québec, Québec.
- Lord, J.** 1984. The kids ate caviar. The story of Manitoba's mighty sturgeon . . . then and now. Nature Canada 13: 19-22.
- MacKay, H. H.** 1963. Fishes of Ontario. Ontario Department of Lands and Forests, Toronto.
- Magnin, É.** 1963. Recherches sur la systématique et la biologie des Acipenseridés: *Acipenser sturio* Linnaeus, *Acipenser oxyrinchus* Mitchell, *Acipenser fulvescens* Rafinesque. Annales Statistiques Centre d'Hydrobiologie Appliquée, Paris 9: 8-242.
- Magnin, É.** 1964. Premier inventaire de la faune ichthyologique du lac et de la rivière Waswanipi dans le centre-ouest de la province du Québec. Le Naturaliste canadien 91: 273-308.
- Magnin, É.** 1966a. Quelques données biologiques sur la reproduction des esturgeons *Acipenser fulvescens* de la rivière Nottaway. Canadian Journal of Zoology 44: 257-263.
- Magnin, É.** 1966b. Recherches sur les cycles de reproduction des esturgeons de la rivière Nottaway, tributaire de la Baie-James. Verhandlungen Internationalen Verein Limnologen 16: 1018-1024.
- Magnin, É.** 1977. Croissance, régime alimentaire et fécondité des esturgeons *Acipenser fulvescens* Raf. du bassin hydrographique de la Grande rivière (Québec). Le Naturaliste canadien 104: 419-427.
- Magnin, É.** 1980. Écologie des eaux douces du territoire de Baie-James. Société d'énergie de la Baie-James. Service environnemental, Montréal, Québec.
- Mongeau, J. R., and G. Massé.** 1976. Les poissons de la région de Montréal, la pêche sportive and commerciale, les ensemencements, les frayères, la contamination par la mercure et les PCB. Québec Ministère de la tourisme, de la chasse et de la pêche, Wildlife Management Service, Montréal, Technical Report Number 06-13.
- Mongeau, J. R., A. Courtemanche, G. Massé, and B. Vincent.** 1974. Cartes de répartition géographique des espèces de poissons au sud du Québec, d'après les inventaires ichthyologiques effectués de 1963 à 1972. Québec Ministère de la tourisme, de la chasse et de la pêche, Wildlife Management Service, Montréal, Technical Report Number 06-4.
- Mongeau, J. R., J. Leclerc, and J. Brisebois.** 1982. La dynamique de la reconstitution des populations de l'esturgeon jaune *Acipenser fulvescens* du lac des Deux Montagnes, Province du Québec, de 1964 à 1979. Québec Ministère de la tourisme, de la chasse et de la pêche, Wildlife Management Service, Montréal, Technical Report Number 06-33.
- Ono, D., J. D. Williams, and A. Wagner.** 1983. Vanishing fishes of North America. Stone Wall Press, Washington.
- Parks, N. B.** 1978. The Pacific northwest commercial fishery for sturgeon. Maritime Fishery Review 40: 17-20.
- Priegel, G. R., and T. L. Wirth.** 1971. The lake sturgeon. Its life history, ecology and management. Wisconsin Department of Natural Resources, Madison, Wisconsin. Publication 270-70.
- Roussow, G.** 1955. Les esturgeon du fleuve Saint Laurent. En comparaison avec les autres espèces d'Acipenseridés. Pêche, biométrie, croissance, age, migration, pisciculture. Québec Ministère de la tourisme, de la chasse et de la pêche, Montréal, Québec.
- Roussow, G.** 1957. Some considerations concerning sturgeon spawning periodicity. Journal of the Fisheries Research Board of Canada 14: 553-572.
- Scott, W. B., and E. J. Crossman.** 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
- Semakula, S. N., and P. A. Larkin.** 1968. Age, growth, food and yield of the White Sturgeon (*Acipenser transmontanus*) of the Fraser River, British Columbia. Journal of the Fisheries Research Board of Canada 25: 2589-2602.
- Smith, H. M., and M. M. Snell.** 1891. Review of fisheries of the Great Lakes in 1885. Report of the U.S. Fisheries Commission for 1887.
- Sopuck, R. D.** 1981. The sturgeon in northern Manitoba. Manitoba Department of Natural Resources Conservation Comment, Winnipeg, Manitoba.
- Sunde, L. A.** 1959. The sturgeon fishery in Manitoba with recommendations for management (Analysis of Nelson River data 1953-1956). Manitoba Department of Mines

and Natural Resources, Fisheries Branch, Winnipeg, Manitoba.

Threader, R. W., and C. S. Brousseau. 1983. Biology and management of the Lake Sturgeon in the Moose River, Ontario. Ontario Ministry of Natural Resources Unpublished Research Report, Toronto.

Vladykov, V. D., and J. R. Greely. 1963. Order Acipenseridae. Fishes of the Western North Atlantic. Memoirs of the Sears Foundation for Maritime Research 1: 24-60.

Wright, R. 1892. Preliminary report on the fish and fisheries of Ontario. Report of the Ontario Game and Fish Commission, Toronto, Ontario.

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Status of the Lake Lamprey, *Lampetra macrostoma*, in Canada*

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Beamish, R. J. 1987. Status of the Lake Lamprey, *Lampetra macrostoma*, in Canada. Canadian Field-Naturalist 101(2): 186-189.

Lampetra macrostoma (Lake Lamprey) is a newly discovered and rare species of freshwater parasitic lamprey. It is a derivative of *Lampetra tridentata* (Pacific Lamprey) and differs from it morphologically primarily by the large size of its disc, and physiologically because of its freshwater habitat. It feeds heavily on freshwater salmonids and poses a definite threat to them if it is introduced into other systems.

La lamproie à grand disque, *Lampetra macrostoma* est une espèce rare de lamproie parasitique dulçaquicole récemment découverte. Elle tire son origine de la lamproie du Pacifique, *Lampetra tridentata*, dont elle diffère surtout par la grande taille du disque et son cycle vital en eau douce. Cette lamproie est un important prédateur de salmonidés dulçaquicoles et constitue une menace certaine pour les autres salmonidés si elle vient qu'à s'introduire dans d'autres systèmes aquatiques.

Key Words: Lake Lamprey, *Lampetra macrostoma*, parasitic lampreys, British Columbia, rare and endangered species, petromyzontiformes.

The Lake Lamprey, *Lampetra macrostoma*, (Figure 1) is endemic to Vancouver Island and the Lake Cowichan watershed. It is the only known *L. tridentata* (Pacific Lamprey) derivative in Canada and the only known freshwater parasitic lamprey in British Columbia. A number of *L. tridentata* derivatives are found in southern Oregon and northern California. These derivatives have freshwater parasitic and freshwater nonparasitic life histories. Several are rare and one, *Lampetra minima*, was purposely eradicated and now is extinct. While some may feel that all parasitic lampreys should be eradicated, it must be remembered that lampreys are one of the most successful groups of living fishes. The Lake Lamprey and the other *L. tridentata* derivatives offer an excellent opportunity to study the reasons for the success of lampreys and it is therefore important that these rare species be conserved.

Distribution

The Lake Lamprey has been found only in two adjacent lakes (Lake Cowichan and Mesachie Lake) on Vancouver Island, British Columbia (Figure 2). The larger lake is the 34-km-long Lake Cowichan, which has a mean depth of 51 m and a maximum depth of 150 m. The much smaller lake, Mesachie Lake, is 2.7 m long with a surface area of approximately 59 hectares and drains into Lake Cowichan.

Protection

There are no existing proposals for either the protection or the control of this species. If the

distribution is confined to the two known lakes, the species is rare. It is a potentially serious source of salmonid mortality, and should not be allowed to enter other lakes.

Population Size and Trends

No population estimates exist. The incidence of wounding and scarring suggests that the population fluctuates. There is no indication that the population is in danger of extinction but research on this species should be continued. Further study is needed to clarify its biological and taxonomic relationships with its close relative, the Pacific Lamprey.

Habitat

The known distribution is extremely restricted. It is probable that its distribution results from anomalous patterns of glaciation during the last glacial period. There is no indication that habitat loss is reducing distribution; in fact, increasing siltation of lakes and rivers may be increasing habitat for ammocoetes. The species is a lake spawner and would be affected by loss of shallow-water gravelly areas used for spawning. Spawning may also occur in some creeks tributary to the system.

General Biology

Like all lampreys, the Pacific Lake Lamprey breeds only once. It is not possible to age lampreys accurately; however, an "educated guess" is that the species is about eight years old when it reproduces (six years as a larva and two years as a young adult and adult). As with all lampreys, it is believed that population size influences reproduction success as well as the sex ratio.

*Rare status assigned by COSEWIC April 1986.



FIGURE 1. Head and tail region of a 22.8-cm *Lampetra macrostoma* photographed live and captured in Lake Cowichan, November 1980.

Lampreys appear to be able to increase abundance relatively rapidly, indicating a relatively high yield per recruit at low population levels. Also, lampreys are known to be at least 300 million years old; hence, they are one of our most primitive and successful fishes. This indicates that the Lake Lamprey may be resourceful and capable of adjusting to a variety of pressures.

The biology of the Lake Lamprey has not been well studied; however, it is known that spawning occurs from May to August and, during this period, there is an aggregation of males and females. Spawning has been observed at the mouth of several creeks. Water spawning area varied from 20 cm to more than 2 m. Spawning occurred in the shallow water, but could not be studied in the deeper water. Larval lamprey are found in the lake in the vicinity of creeks and occasionally in the creeks, but always close to the lake. No Lake Lampreys have been found more than a few hundred metres upstream of the lake in the few creeks that have been examined, and there were no lampreys in the creek connecting Mesachie Lake and Lake Cowichan, suggesting that this species spawns in the lake and young remain in the lake. Spawning behaviour as observed in the laboratory is similar to the behaviour reported for *L. richardsoni*, Western Brook Lamprey, and *L. tridentata* by Pletcher (1963). It is only during the spawning period that adult lampreys are easily captured. Behaviour of young adults at other times is largely unknown and unstudied. Feeding juveniles have been caught by anglers when they have towed live fish on "stringers"

behind their boat. While it is rare to land live lampreys in this manner, one fisherman landed three live Lake Lampreys that had attached themselves to a live Cutthroat Trout, *Salmo clarki*.

The Lake Lamprey metamorphoses into a young adult from July to October. From October to the spring of the following year, the young adult probably remains in the gravel. In the spring, the young adult begins feeding and attacks large numbers of young salmonids including age 1 and 2 Coho Salmon, *Oncorhynchus kisutch*. Feeding continues throughout the summer and fall and into the winter. It is believed that spawning occurs the following year, two years after metamorphosis.

Feeding juvenile adults readily attack resident fishes. Carl (1953) reported that eight out of ten fish examined from Lake Cowichan had evidence of lamprey attacks. Beamish (1982) observed that up to 50% of the salmonids captured in Mesachie Lake throughout the year had evidence of lamprey attacks. The large percentage of wounded and scarred fish may indicate that this lamprey feeds without killing a high percentage of its hosts. Since salmonids remain in the lake and the lake is still popular for sport fishermen, it appears that the Lake Lamprey coexists with its hosts in a manner similar to the landlocked Sea Lamprey, *Petromyzon marinus*, in Cayuga Lake, New York (Wigley 1959). Beamish (1982) reported that in one sample of 221 salmonids 15% had wounds that penetrated deeply into the body and could cause mortality. Thus some mortality does occur. Although the species prefers Coho Salmon and Cutthroat

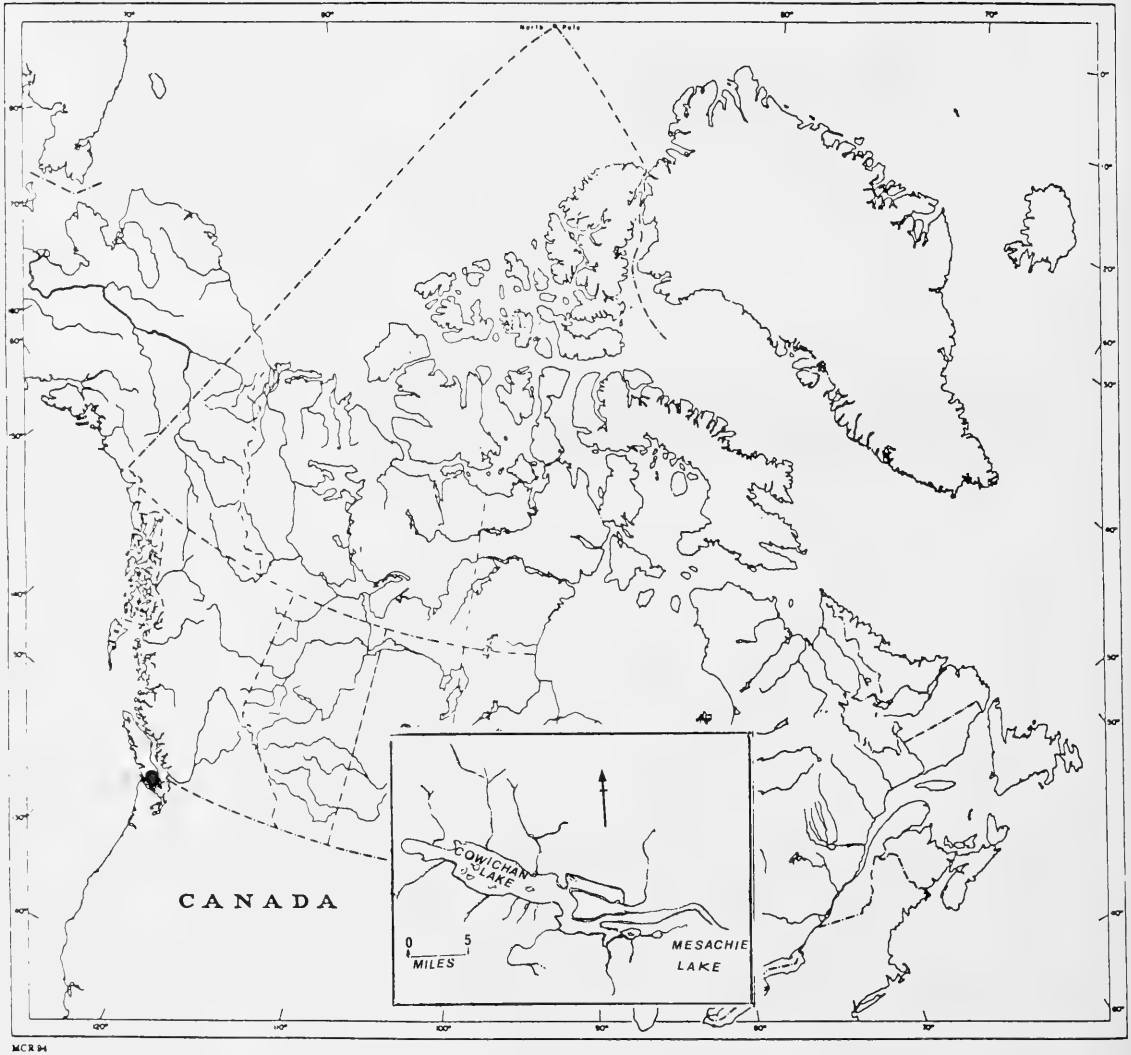


FIGURE 2. Distribution of the Lake Lamprey, *Lampetra macrostoma*.

Trout, other salmonids such as Dolly Varden, *Salvelinus malma*, are attacked.

No Pacific Lamprey adults or ammocoetes have been found in the same areas as the Lake Lamprey. Pacific Lamprey do exist in the river flowing out of Lake Cowichan, but it is unknown if they occur in the lake. The timing and length of spawning period of the Lake Lamprey is different from that of the Pacific Lamprey that occur in the same area of British Columbia (Beamish 1980). The lake spawning habit and the late spawning period could offer effective isolation from the Pacific Lamprey.

It is important to note that this lamprey readily

survives and feeds as a young adult in freshwater whereas its close relative, the Pacific Lamprey, can not be kept as a young adult in freshwater (Beamish 1980, unpublished data).

Limiting Factors

Unknown.

Special Significance of the Species

The Lake Lamprey is endemic to Canada and is only known to exist on Vancouver Island. It is of considerable scientific interest, but it is unlikely that the general public in Canada would understand or

support its preservation and protection. Its occurrence in Lake Cowichan is of particular interest to the understanding of the glacial history of Vancouver Island. It is probable that this species will also provide important information about evolutionary processes in lampreys.

Evaluation

Comments from fishermen about the incidence of observed lamprey wounds suggest that the population fluctuates. Although no population estimates exist, there has been no indication that there is a long-term decline in numbers. Due to its restricted distribution, the species is rare in Canada.

Literature Cited

- Beamish, R. J.** 1980. The adult biology of the river lamprey (*Lampetra ayresii*) and the Pacific lamprey (*Lampetra tridentata*) from the Pacific coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences 37: 1906-1923.
- Beamish, R. J.** 1982. *Lampetra macrostoma*, a new species of freshwater parasitic lamprey from the west coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences 39(5): 736-747.
- Carl, G. C.** 1953. Limnobiology of Cowichan Lake, British Columbia. Journal of the Fisheries Research Board of Canada 9: 417-449.
- Pletcher, F. I.** 1963. The life history and distribution of lampreys in the Salmon and certain other rivers in British Columbia, Canada. M.Sc. thesis, University of British Columbia, Vancouver, British Columbia.
- Wigley, R. L.** 1959. Life history and distribution of lampreys of Cayuga Lake, New York. U.S. Fish and Wildlife Service Fisheries Bulletin 154 (Volume 59): 561-617.

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Status of the Silver Chub, *Hybopsis storeriana*, in Canada*

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The Silver Chub, *Hybopsis storeriana*, is rare in Canada. It is found in lakes Erie and St. Clair in southwestern Ontario and has been reported from the Red and Assiniboine rivers of Manitoba. These records represent the northeastern and northern limits, respectively, of the range of this species in North America. The status of the Manitoba populations is uncertain but reproducing populations are known from Ontario. The latter may have suffered a decline in the last few decades because of habitat deterioration; reproducing populations are present in lakes St. Clair and Erie although in low abundance. The Silver Chub is not specifically protected in Canada, although general protection is afforded through the fish habitat sections of the Fisheries Act.

Le méné à grandes écailles, *Hybopsis storeriana*, est rare au Canada. Il peuple les lacs Érié et Sainte-Claire dans le sud-ouest de l'Ontario; il a été signalé aussi dans les rivières Rouge et Assiniboine au Manitoba. Ces endroits représentent les limites nord-est et nord, respectivement, de l'aire de répartition de cette espèce en Amérique du Nord. La situation des populations du Manitoba est incertaine, mais des populations reproductrices sont présentes en Ontario. Toutefois, ces dernières ont montré des signes de déclin dans les dernières décennies à cause de la détérioration de l'habitat, mais des populations reproductrices habitent le lac St. Clair et le lac Érié. Cependant, l'abondance est faible. Le méné à grandes écailles ne bénéficie pas d'une protection particulière au Canada, mais il est protégé de façon générale par l'article de la Loi sur les pêcheries qui traite de protection de l'habitat du poisson.

Key Words: Silver Chub, *Hybopsis storeriana*, cyprinids, rare, Ontario.

The Silver Chub, *Hybopsis storeriana*, is a small cyprinid (Figure 1) with marginal distribution in Ontario. These fish seldom exceed 15 cm in length and prefer large sandy or silty rivers. Since the species was always rare in Ontario it has been of little interest to the general public. Published information on its biology is limited. Available literature on the species is reviewed by Scott and Crossman (1973).

Distribution

The Silver Chub is a fish of east-central North America. In Canada, the species has been found in southern Manitoba in the Red and Assiniboine river systems and in southwestern Ontario in lakes Erie and St. Clair and their drainages (Figures 2 and 3). These distributions represent the northern and northeastern extremities of the species range, respectively. Parker and McKee (1980) summarize locality records for the Silver Chub in Canada; Lee et al. (1980) give the United States records as well.

Protection

International: considered to be threatened in Michigan and South Dakota (Miller 1972) and

endangered in Ohio (Ohio Department of Natural Resources 1976).

National: not protected in Canada, although the fish habitat sections of the Fisheries Act do afford general protection.

Population Size and Trends

The Silver Chub was considered to be common in the western basin of Lake Erie during the early 1960s. However, efforts by the Royal Ontario Museum (ROM) and the Ontario Ministry of Natural Resources (OMNR) to obtain specimens from commercial fishermen in Lake Erie during the latter half of the decade were unsuccessful. The last specimen taken in Canada during this period was collected in Lake Erie at Port Stanley in 1960 by the National Museum of Natural Sciences.

The apparent decline of the Silver Chub in Lake Erie between the 1950s and early 1960s and the scarcity of specimens collected during the late 1960s and early 1970s led Scott and Crossman (1973) to believe that this species was rare in Lake Erie. Kinney (1954) estimated a minimum of 20 Silver Chub per acre in the western basin of Lake Erie. McAllister and Gruchy (1977) listed this species as endangered in Canada. Data compiled by the Ontario Ministry of Natural Resources in the 1970s confirmed the

*Rare status approved and assigned by COSEWIC 2 April 1985.

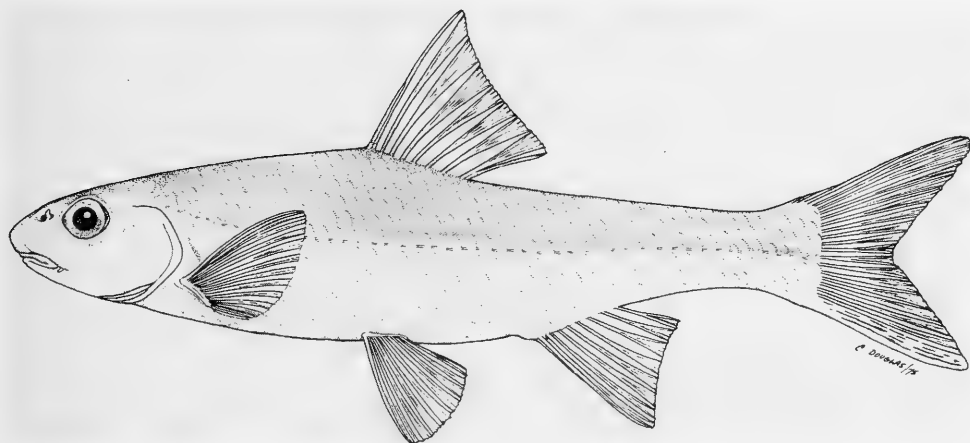


FIGURE 1. Silver Chub, *Hybopsis storeriana* (drawing by C. H. Douglas; courtesy D. E. McAllister, National Museum of Natural Sciences).

presence of the species and suggest that there are reproducing populations in Lake St. Clair and the western basin of Lake Erie. However, catch-per-unit-effort figures indicate that abundance in both lakes is low (Parker and McKee 1980).

Recent inventory activity by the ROM and OMNR has in fact revealed populations in western Lake Erie which were unknown when Scott and Crossman (1973) noted the species as rare (Crossman, Goodchild, personal communications). Other populations in Lake St. Clair have also been found (Crossman, personal communication). These fish are caught only with large gear in the lakes and the opportunity to obtain records and specimens is therefore limited. They are, however, used as bait fish by anglers in Lake St. Clair and may be common in some localities (Goodchild, personal communication).

The continued existence of this species in Manitoba is uncertain. The Manitoba Department of Natural Resources believes that if the species is present, it is extremely rare (Parker and McKee 1980).

Habitat

In Ontario, the Silver Chub has been collected only from open lake waters; elsewhere, it has been captured in stream and river habitats. Collections from Lake St. Clair and Lake Erie were mostly from water depths under 10 meters, although capture depths up to 20 meters are reported (Woolman 1895; Fish 1935; Trautman 1957). Kinney (1954) suggested that Silver Chub preferred the shallow waters of the western basin of Lake Erie to other areas of the lake. Substrate composition ranges from gravel to silt. This species

may be intolerant of low dissolved oxygen levels, and seasonal water temperature fluctuations are also thought to limit its distribution. Kinney (1954) considered that the Silver Chub requires water temperatures above 4 to 10°C for six to seven months of the year and above 21°C for at least three months to sustain normal growth and permit reproduction.

General Biology

The best summary account of the biology of the Silver Chub is given by Parker and McKee (1980) and the following account is largely extracted from that source.

The largest Canadian specimen is about 20 cm in total length. Lifespan is 3+ years and gravid females are slightly heavier than adult males. Growth rate declines from 60 mm per year for fish 1+ to 25 and 15 mm per year for fish 2+ and 3+ years. Spawning habits are not known but it is thought that spawning occurs in open waters in the Great Lakes drainage during early summer. Fish aged 2+ years caught in Canada were sexually mature. Kinney (1954) estimated egg numbers as 355 plus 746 times the ovary weight in grams. Kinney (1954) also reported on diet items for western Lake Erie specimens. Young-of-the-year fed on copepods (40% by volume), tentipeded larvae and pupae (35%) and *Daphnia* (10%). Approximately two-thirds of the adult diet consisted of Ephemeroptera nymphs (65% of which were *Hexagenia*). Minor components were molluscs, *Daphnia*, gammarids and small fish. Following the decline of *Hexagenia* populations in Lake Erie during the 1950s, greater use was made of chironomids and gammarids as a food supply (Scott and Crossman

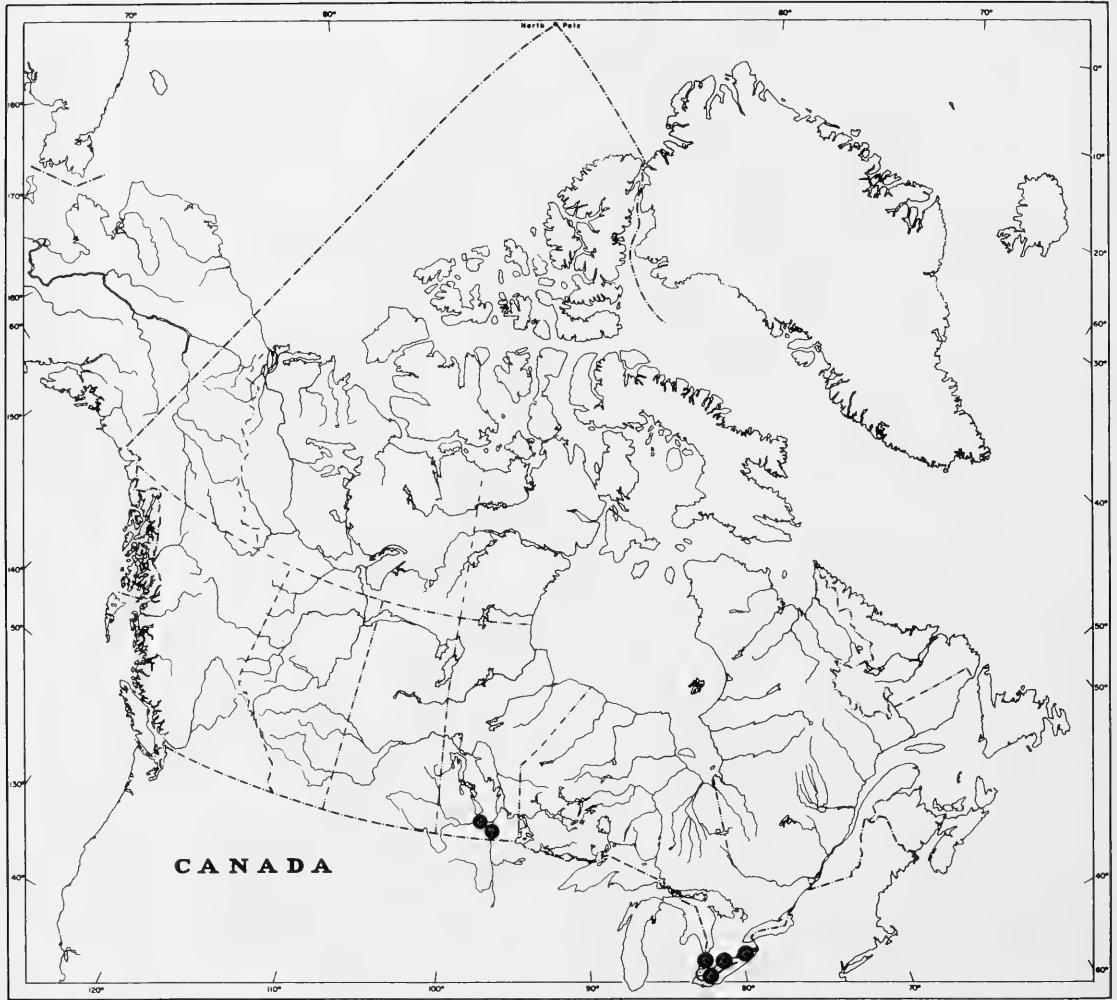


FIGURE 2. Canadian distribution of the Silver Chub.

1973). Kinney (1954) reported the following predators of the Silver Chub: Burbot, *Lota lota*, Sauger, *Stizostedion canadense*, and Walleye, *Stizostedion vitreum*.

Limiting Factors

Temporary hypoxic water conditions have been reported from the western Lake Erie basin on several occasions (Carr et al. 1955; Leach and Nepszy 1975), and Kinney (1954) believed that such conditions could affect Silver Chub population stability. The disappearance of a major diet component (*Hexagenia*) in the 1950s may have led to reductions in the populations in Lake Erie.

Special Significance of the Species

Populations in Canada represent the most northern (Manitoba) and northeastern (Lake Erie) for this species. The Silver Chub serves as food for a number of sport fishes and is, or was, a popular bait fish in the United States and locally in Lake St. Clair.

Evaluation

Reproducing populations of Silver Chub are present in lakes Erie and St. Clair. The status of the Manitoba populations is uncertain. Available information does not allow a definitive analysis of population trends.



FIGURE 3. Collection records of *Hybopsis storeriana* in Ontario.

Populations of the Silver Chub suffered an apparent decline in the 1950s and 1960s in Canadian waters; this may have been related to habitat deterioration. The current status is unknown. Reproducing populations are present, but the abundance may be low. The species is liable to suffer further population reduction as it is restricted to heavily populated parts of Canada.

Based on the information at hand it is recommended that the Silver Chub be classified as rare in Canada with the realization that they could easily become endangered if further habitat degradation occurs.

Acknowledgments

This paper was extracted from a more detailed discussion of the species in Parker and McKee (1980). We would like to thank G. Goodchild of the Ontario Ministry of Natural Resources and E. J. Crossman of the Royal Ontario Museum for their helpful communications on the status of the species in Ontario. Financial support was provided through Supply and Services Canada, Department of

Fisheries and Oceans and the National Museum of Natural Sciences.

Literature Cited

- Carr, J. F., V. C. Applegate, and M. Keller. 1965. A recent occurrence of thermal stratification and low dissolved oxygen in western Lake Erie. *Ohio Journal of Science* 65: 319-327.
- Fish, M. P. 1932. Contribution to the early life histories of sixty-two species of fishes from Lake Erie and its tributary waters. *Bulletin of the United States Bureau of Fisheries* 10 (Volume 47): 293-393.
- Kinney, E. M. S. 1954. A life history of the silver chub, *Hybopsis storeriana* (Kirtland), in western Lake Erie with notes on associated species. Ph.D. thesis, Ohio State University, Columbus, Ohio.
- Leach, J. H., and S. J. Nepszky. 1976. The fish community in Lake Erie. *Journal of the Fisheries Research Board of Canada* 33(3): 622-638.
- Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina Biological Survey Publication Number 1980-12.
- McAllister, D. E., and C. G. Gruchy. 1977. Status and habitat of Canadian fishes in 1976. Pages 151-157 in

- Canada's threatened species and habitats. *Edited by* T. Mosquin and C. Suchal. Canadian Nature Federation Special Publication. Number 6.
- Miller, R. R.** 1972. Threatened freshwater fishes of the United States. *Transactions of the American Fisheries Society* 101(2): 239-252.
- Ohio Department of Natural Resources.** 1976. Endangered wildlife in Ohio. Ohio Department of Natural Resources, Division of Wildlife, Publication 316.
- Parker, B., and P. McKee.** 1980. Rare, threatened and endangered fishes in southern Ontario: Status reports. A report for the Department of Supply and Services, Department of Fisheries and Oceans, and National Museum of Natural Sciences. Beak Consultants Limited, Mississauga, Ontario.
- Scott, W. B., and E. J. Crossman.** 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
- Trautman, M. B.** 1957. The fishes of Ohio with illustrated keys. Ohio State University Press, Columbus, Ohio.
- Woolman, A. J.** 1895. A report on the ichthyological investigations in western Minnesota and eastern North Dakota. Report of a United States Fisheries Commission for 1893. Appendix Number 3: 343-373.

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Status of the Bigmouth Shiner, *Notropis dorsalis*, in Canada*

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The Bigmouth Shiner, *Notropis dorsalis*, is rare in Canada but in the United States it has a continuous distribution from eastern Wyoming and Colorado east to Illinois and Wisconsin. Isolated populations occur in Michigan, Ohio, Pennsylvania, West Virginia, and New York. It was first found in Canada in 1968 in tributaries of the Red River drainage system in southwestern Manitoba. The species is abundant in the western half of its range but is decreasing in the east. The Bigmouth Shiner inhabits small prairie-like streams with permanent flow and unstable sandy bottoms. Further distribution is restricted in Canada because conditions in the Red River are not the preferred habitat of the species. Bigmouth Shiners are fast growing fish reaching a total length of 7.5 cm in a maximum lifespan of three years. Most Bigmouth Shiners mature in their second summer and their breeding behaviour is unknown. The species is characterized as a bottom feeder but shows little selectivity in its diet. Possible limiting factors include water quality and lack of critical habitat.

Le méné à grande bouche, *Notropis dorsalis*, rare au Canada, se retrouve partout aux Etats-Unis, de l'est du Wyoming et du Colorado à l'Illinois et au Wisconsin. On trouve des populations isolées au Michigan et Ohio, en Pennsylvanie, en Virginie occidentale et dans l'Etat de New York. C'est en 1968 qu'on l'a observé pour la première fois au Canada, où il habite les tributaires du bassin de la Rivière Rouge dans le sud-ouest du Manitoba. L'espèce est abondante dans le secteur ouest de son aire de répartition, mais décroît en allant vers l'est. Le méné à grande bouche habite les petits cours d'eau permanents typiques des prairies, dont le fond est sablonneux et instable. Sa dispersion plus avant est limitée au Canada, la Rivière Rouge ne présentant pas les caractéristiques de son habitat préféré. Les ménés à grande bouche croissent rapidement, atteignant une longueur totale de 7.5 cm au cours d'une existence maximale de trois ans. La plupart des ménés à grande bouche deviennent matures au cours de leur second été, mais leurs habitudes de reproduction sont inconnues. On classe l'espèce parmi celles qui se nourrissent au fond des cours d'eau, mais elle n'a pas de régime très sélectif. Les facteurs limitatifs possibles comprennent la qualité de l'eau et l'étendue de l'habitat vital.

Key Words: Bigmouth Shiner, *Notropis dorsalis*, cyprinids, rare species, Manitoba.

The Bigmouth Shiner, *Notropis dorsalis*, is a plains species of the minnow family which ranges in length from 5.1 to 7.5 cm. They are essentially fishes of shallow waters in creeks and small rivers, where they feed primarily on insects and plant material. These fish (Figure 1) are a pale olive to straw-yellow colour dorsally, the sides are silvery and the ventral surface silvery to milk-white. The scales may be darkly edged and the fins are transparent. A distinct mid-dorsal stripe and dusky lateral stripe may be seen. The mouth is large and horizontal, the head being vertically flattened with the eyes pointed somewhat upwards. Where common, they could easily be mistaken for other similar species such as the Mimic Shiner, *Notropis volucellus*, the Sand Shiner, *N. stramineus*, or the River Shiner, *N. blennioides*. Breeding males may be identified by small tubercles scattered over the head (see Trautman 1957, 1981).

Distribution

The range of the Bigmouth Shiner is continuous from southwestern Manitoba, eastern Wyoming and

Colorado east to Illinois and Wisconsin but discontinuous from there eastward. Isolated populations occur in both the Upper and Lower peninsulas of Michigan, northern Ohio, western Pennsylvania, northern West Virginia (Hubbs and Lagler 1958) and New York (Gilbert 1980: Figure 1). Within this range three subspecies of *Notropis dorsalis* can be distinguished regionally (Hubbs and Lagler 1958).

The western Bigmouth Shiner (*N. d. ptolepis*) occurs in abundance in the Platte River system of the Great Plains in Colorado and Wyoming (Hubbs and Lagler 1958).

The Central Bigmouth Shiner (*N. d. dorsalis*) is found in Missouri, northeastern Kansas, parts of Nebraska, the Red River system of North and South Dakota (Bailey and Allum 1962) and Manitoba (Fedoruk 1970). The range extends eastward through the watersheds of the Mississippi River in Wisconsin, Iowa and Illinois; through the watersheds of the Wabash River in Illinois to the Great Lakes basin (Fox River in Wisconsin); to the waters in the Lake Superior drainage at the base of the Keweenaw Peninsula, Michigan; to the Manistique River system in the Lake Michigan drainage of upper Michigan; to

*Rare status approved and assigned by COSEWIC April 1985.

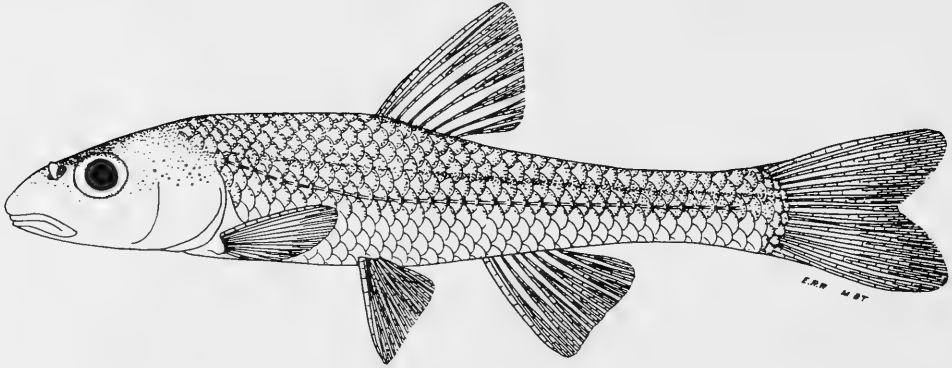


FIGURE 1. Bigmouth Shiner, *Notropis dorsalis* [from Trautman (1957), by permission Ohio State University Press].

the Black and Rocky rivers in Ohio; and to the tributaries of Lake Erie in New York (Hubbs and Lagler 1958).

Isolated populations of the Eastern Bigmouth Shiner (*N. d. keimi*) occur in the Allegheny river system of Pennsylvania and New York, the Genesee River and Oneida Lake in the Lake Ontario drainage of New York, and in northern West Virginia.

Hinks (1943) first included *N. dorsalis* as a possible Manitoba species based on its occurrence in tributaries of the Red River in North Dakota, but it was not until 1970 that the first identified specimens were reported in Canada. Fedoruk (1970) collected 84 specimens of *N. dorsalis* at five locations in Manitoba waters of the Pembina River and two of its tributaries (Figures 2 and 3). All specimens were identified as *N. d. dorsalis* based on the presence of exposed predorsal scales. The Pembina River is a low gradient stream, 78 cm/m, with interspersions of sandy and silty substrata. Bigmouth Shiners were collected from sites in or near sandy areas. The Bigmouth Shiner has apparently not penetrated farther into Manitoba due to its preference for sandy substratum. Waters in the Red River basin have muddy bottoms characteristic of glacial lake origins. Alternately, it is possible that if this species occurs in only isolated populations it may have been overlooked or mistaken for *N. stramineus* or *N. blennioides* (Fedoruk 1970).

Western populations of *N. dorsalis* are sometimes referred to as a distinct subspecies (*N. d. piptolepis*) which differs from the wide ranging eastern and central subspecies (*N. d. dorsalis* and *N. d. keimi*) primarily in having the nape naked or embedded with predorsal scales (Trautman 1957; Pfeiffer 1971; Gilbert 1980). This pattern of variation suggests that *N. dorsalis* was separated into eastern and western

populations some time in the past. Ancestral stocks of *N. d. piptolepis* survived the last glacial period in the unglaciated western tributaries of the Missouri River while ancestral stocks of *N. d. dorsalis* survived not far south of the glacial front in the eastern or western part of the Mississippi River (Pfeiffer 1971). During late post-glacial times a xerothermic period occurred which favoured the eastward invasion by the Bigmouth Shiner into Michigan, Ohio, Pennsylvania and New York. Later, a westward retreat left isolated populations in the east (Trautman 1957).

Protection

No specific protection currently exists for the Bigmouth Shiner in Canada other than general protection provided under the fish habitat section of the Fisheries Act.

Population Size and Trend

Current literature indicates the Bigmouth Shiner is abundant in the western half of its range but is decreasing in numbers to the east (Gilbert 1980). Trautman (1957) reports that E. L. Wickliff collected the first known specimen of the Bigmouth Shiner in Ohio in 1922 from the west branch of the Black River. Trautman (1957) assumes the Bigmouth Shiner was common in the late 1800s but may have been misidentified. Unpublished notes of McCormick found in 1931 contain a list of Lorain County fishes, including *Notropis gilberti* = *Notropis dorsalis* (Trautman 1957). Trautman (1957) found the Bigmouth Shiner to be abundant (150 specimens collected in one hour) in the west branch of the Black River in 1928. Since 1928, he has observed the reduction of the Ohio range of the Bigmouth Shiner due to the invasion and great increase in number of the



FIGURE 2. Canadian distribution of the Bigmouth Shiner.

Silverjaw Minnow, *Ericymba buccata*, into territory formerly occupied by the Bigmouth Shiner (Trautman 1981). Since 1940, none have been taken in the Black River and only one in the Rocky River, suggesting this population may be on the verge of extirpation in both streams (Trautman 1981). But since 1952, it has continued to be present in the west branch and in the lower half of the Rocky River (Trautman 1981).

Bigmouth Shiners were relatively uncommon (occurring in 3.9% of samples) in Oneida Lake, New York, between 1916 and 1927 (Adams and Hankinson 1928) and no confirmed specimens were taken by any method from 1955 to 1974, implying that they may

have been extirpated (Clady 1976). Starrett (1950a) found the Bigmouth Shiner to be one of the most successful fish in Bonne County, Iowa, so far as wide distribution and abundance are concerned. It was abundant in the Des Moines, Cedar, Iowa, Skunk and other watersheds.

The species was absent from collections made in northwestern Missouri in the early 1940s; however, Pflieger (1971) found the species to be widespread and abundant in the till plains, indicating it is expanding its range in Missouri. Mills et al. (1978) first reported the Bigmouth Shiner from Big River in east-central Missouri. The rarity of the Bigmouth Shiner in northeastern Kansas is difficult to understand because

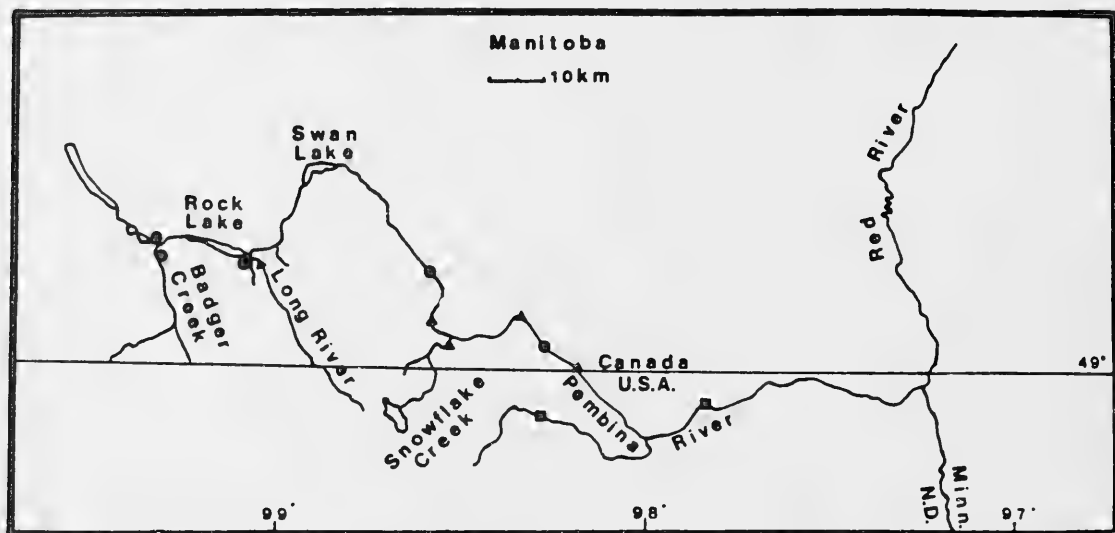


FIGURE 3. Collection records of the Bigmouth Shiner in Manitoba (adapted from Fedoruk 1970).

- Sites where *N. dorsalis* was not found
- Sites where *N. dorsalis* was collected by Copes and Tubbs (1966).
- ▲ Sites where *N. dorsalis* was found.

it is abundant in Iowa, northeastern Nebraska, and most of the Platte River system (Metcalf 1966).

Johnson and Becker (1970) report *N. dorsalis* to be recently established in the east-central streams within the Lake Michigan drainage of Wisconsin. The fish is widely distributed in eastern South Dakota where it has been taken in all the major drainages as well as Antelope Creek of the Niobara drainage and was once caught in the Missouri drainage (Bailey and Allum 1962). The failure of early collectors to note it suggests it has increased in abundance and has extended its range. *N. dorsalis* was first recorded in North Dakota by Hankinson (1929) who obtained a few specimens from the Pembina River. Copes and Tubb (1966) found Bigmouth Shiners in 11% of their collections from tributaries of the Red River in North Dakota: the Pembina, Turtle, Goose, Rush, Maple and Sheyenne rivers.

The Bigmouth Shiner was not discovered in Canada until 1968 (Fedoruk 1970) and this population is restricted to the Pembina and Woody rivers in southwestern Manitoba (Scott and Crossman 1973). It is improbable that the Bigmouth Shiner has penetrated farther into Manitoba, as local conditions are prohibitive. There are insufficient data to indicate any change or trend in Canadian populations.

Habitat

N. dorsalis occurs most abundantly in small prairie-like streams with permanent flow and unstable sandy bottoms (Hubbs 1941; Bailey and Allum 1962; Fedoruk 1970; Pfeiffer 1971; Mendelson 1975). Mendelson (1975) collected Bigmouth Shiners in abundance in Roxbury Creek, Wisconsin, a narrow stream (4 m wide) rarely exceeding 1 m in the deepest pools. It is usually rare or absent in larger streams (Becker 1959; Cross 1967; Mendelson 1975) with a tendency for decreasing abundance with increasing stream width greater than 3 m. However, Starrett (1950a) considered *N. dorsalis* one of the third most abundant minnows in the Des Moines River (37.5–60 m width) and Johnson and Becker (1970) report the Bigmouth Shiner common in sandy streams of medium size in the Mississippi drainage.

Copes and Tubb (1966) collected Bigmouth Shiners from tributaries of the Red River in North Dakota in all types of water but most abundantly in slightly turbid water with a sand bottom. Similarly, Mills et al. (1978) found a small number of specimens in turbid water at the mouth of the Big River, Missouri. More typically, Mendelson (1975) reported Bigmouth Shiners in clear pools with gentle currents (7.5–30 cm.s⁻¹) and unsilted bottoms.

Infrequently *N. dorsalis* may inhabit small streams with silt bottoms (Eddy and Underhill 1943) or sand

bottoms overlaid with silt (Gilbert 1980). Cross and Minckley (1958) collected Bigmouth Shiners from small pools with mud bottoms approximately 360 m above the confluence of Little Walnut Creek and the Missouri River while none were found farther upstream where pool bottoms were composed of rubble or gravel. Although Hanson and Campbell (1963) and Cross and Minckley (1958) associated *N. dorsalis* with small pools, Mendelson (1975) reported that they showed a strong preference for shallow water areas upstream from pools where they are usually found near the bottom (Hubbs and Walker 1942; Starrett 1950a). Furthermore, Bigmouth Shiners were sometimes collected over recently formed sandbars, suggesting an ability to make use of new habitats.

Generally not abundant in lakes (Eddy and Underhill 1943), *N. dorsalis* was present in lakes in Bargara and Houghton counties and in the Sturgeon River system, all in the Lake Superior watershed, Michigan (Taylor 1954). Griswold (1963) reported Bigmouth Shiners along the shore of Clear Lake, a shallow eutrophic lake in north-central Iowa, and Adams and Hankinson (1928) collected specimens in Oneida Lake, New York.

It is difficult to determine trends or rates of change in the habitat of the Bigmouth Shiner. Population trends in the United States suggest an expanding habitat in the central plains but decreasing habitat quality in the eastern limits of the Bigmouth Shiner's range. Extensive channelization of prairie streams in the till plains at the turn of the century created favourable conditions for the Bigmouth Shiner in Missouri (Pfleiger 1971). Such habitats are also common in southwestern Wisconsin and in the Upper Mississippi Valley (Mendelson 1975). Trautman (1957, 1981) found that the Ohio population decreased markedly in abundance and range due to the invasion of the Silverjaw Minnow into territory formerly occupied by the Bigmouth Shiner. Although once reported to occur in Oneida Lake, New York, by Adams and Hankinson (1928), recent shoreline development and resultant eutrophication have caused the Bigmouth Shiner to become extirpated (Clady 1976). There are insufficient data to suggest trends in the habitat of Canadian populations.

At present, the only habitat protection that exists in Canada is general protection of environmental quality provided under the Clean Environment Act and the Fisheries Act. Further protection of critical habitat might be provided by protection and improvement of water quality and restriction of dam construction and shoreline development.

General Biology

Information on the biology and life history of the Bigmouth Shiner is limited. Bigmouth Shiners are

fast-growing, short-lived fish, with a maximum lifespan of three years (Keeton 1963). In October, Trautman (1957) reported total lengths for fish from Ohio ranging from 28–50 mm for young-of-the-year, 33–63 mm for ages 1+ and 50–70 mm for adults. The largest recorded specimen was 75 mm. Griswold (1963) collected 27 young-of-the-year (28–58 mm) and 8 aged 1+ (52–65 mm) Bigmouth Shiners from Clear Lake, Iowa, between July and September. All specimens collected by Fedoruk (1970) in Manitoba in the summer of 1968 were in the size range of 55–64 mm (S.L.), and presumably were prespawning adults.

Little data are available on the abundance of age groups or sex ratios of *N. dorsalis*. Griswold (1963) found that young-of-the-year accounted for 79% of the fish collected in Clear Lake, Iowa. Starrett (1951) observed a dominant year class of this species in several of the small tributary streams of the Des Moines River, Iowa. Age 0 fish were most abundant in the winter of 1946, but due to unfavourable spawning conditions, age 1+ fish predominated in the fall of 1947.

Observations on the reproductive behaviour and spawning sites of the Bigmouth Shiner have not been documented; however, Pfleiger (1975) suggests this species probably spawns in its second summer in midwater with eggs drifting downstream (Moore 1944). Starrett (1951) classified the bigmouth as a late spawner, spawning in late July through August in Iowa. It spawns from June to July in Kansas (Cross 1967) and Missouri (Pfleiger 1975) and from May to June in Illinois (Gilbert 1980). Mendelson (1975) suggested the possibility of a resident population of *N. dorsalis* that may breed in Roxbury Creek rather than move into the Wisconsin River.

The Bigmouth Shiner, like other species of *Notropis*, shows a strong tendency to school (Pfleiger 1954) and multi-specific assemblages are common (Mendelson 1975). *N. dorsalis* was frequently associated with *Pimephales promelas*, Fathead Minnow, and *N. stramineus* in Kansas (Cross 1967) and in Manitoba (Fedoruk 1970) streams. Starrett (1950a) found Bigmouth Shiners in schools containing *N. stramineus* and *N. spilopterus*, Spotfin Shiner, in the Des Moines River, Iowa. Bigmouth Shiners have also been collected with Sand Shiners in Iowa (Harlan and Speaker 1957) and in Missouri (Hanson and Campbell 1963).

Of four species of *Notropis* (*N. dorsalis*, *N. stramineus*, *N. atherinoides* [Emerald Shiner] and *N. spilopterus*) inhabiting a Wisconsin stream, Mendelson (1975) observed *N. dorsalis* to be the most responsive both to conspecifics and heterospecifics. Each species had sufficient morphological adapta-

tions to permit coexistence. In pools, fish remained in loose aggregations facing the current. *N. dorsalis* showed a strong preference for shallow water areas upstream from the pools (Hubbs and Walker 1942; Starrett 1950a) and moved into shallow water at night, likely due to the presence of emerging insect larvae and increased immunity from terrestrial predators. Characteristically, they swim upstream a short distance and drift back a similar distance. During fall and winter fish migrated upstream, returning downstream in summer (Mendelson 1975).

The Bigmouth Shiner feeds mainly on insects but also on bottom ooze and plant material (Gilbert 1980). Gut content analysis on 35 fish collected by Griswold (1963) from Clear Lake, Iowa, showed little feeding selectivity. The main food items were Cladocera in areas of little submergent vegetation and various vegetable matter where it was available. Later in the summer when insect material became prevalent, it comprised almost 100% of the diet. In samples taken throughout the year 1970-71, Mendelson (1975) found that in all sampling periods the diet consisted more of benthic fauna than of drift. The apparent preference for shallow water areas upstream from pools is reflected by the frequent presence of *Hydropsyche*, *Dicranota*, and the mite *Libertia* all collected primarily from the shallows. In the Des Moines River, Iowa, Starrett (1950b) found that the Bigmouth Shiner consumed bottom ooze, aquatic nymphs and larvae, and Diptera larvae during the summer. There was increased feeding on terrestrial insects near the surface in the fall associated with increased abundance of these insects and the reduction in Ephemeroptera and Trichoptera larvae. Throughout the remainder of the year aquatic nymphs and larvae and Diptera formed an important part of the diet.

Sight is apparently less important than taste in locating food. Pfleiger (1975) reported Bigmouth Shiners in aquaria fed only on or near the bottom. Bigmouth Shiners swim rapidly over the bottom taking in mouthfuls of sand from which they sort out the food and forcefully eject sand from the mouth or through the gill openings. The morphology of the Bigmouth Shiner is consistent with bottom feeding: the mouth is inferior and horizontal so they can easily move about and feed on the bottom (Hubbs 1941). Bigmouth Shiners show a strong preference for particular habitats but there are insufficient data to determine breeding site specialization.

Limiting Factors

Available data suggest Bigmouth Shiners can tolerate little human disturbance. Clady (1976) reported the incidence of the Bigmouth Shiner decreased significantly in Oneida Lake, New York,

due to eutrophication as a result of shoreline development. The Bigmouth Shiner is less susceptible to fluctuating water levels than coexisting species. During periods of flooding in the Des Moines River, Iowa, the Bigmouth Shiner moved from the small streams into the river to avoid isolation in temporary backwaters following flooding and did not undergo pronounced changes in abundance (Starrett 1951). Its susceptibility to severe winters or other special conditions is not known.

Habitat loss and environmental contamination as a result of human disturbance may have been responsible for the reduction in numbers of the Bigmouth Shiner in Oneida Lake, New York (Clady 1976). Floods and silt may be important factors affecting the Bigmouth Shiner population of the Des Moines River, Iowa (Starrett 1951). High water levels during spawning reduce preferred habitats, spawning sites and food availability and may limit, to a considerable extent, the success of reproduction. Silty conditions in the Red River drainage system appear to be limiting further penetration of the Bigmouth Shiner in Canada (Fedoruk 1970).

Species competition is a possible limiting factor. The Bigmouth Shiner and the Silverjaw Minnow are ecological analogs: both occupy the same type of habitat. Trautman (1957, 1981) attributed the decline of the Ohio population of the Bigmouth Shiner to the invasion of the Silverjaw Minnow. There is no published evidence to suggest that predation or parasites are limiting. Infestations of this species by *Neoechinorhynchus rutili* (Samuel et al. 1976) and *Gyrodactylus planensis* (Mayes 1977) were reported in Nebraska.

Special Significance of the Species

The Bigmouth Shiner is not found outside the United States and Canada. It is considered threatened in New York (Clady 1976) and is almost extirpated from Ohio waters (Trautman 1957). The Canadian population is the most northern of the Bigmouth Shiner populations. Although the genus *Notropis* is not likely to be threatened, 29 *Notropis* species are listed as threatened in at least one state in the United States (Miller 1972).

The degree of public interest in this species is low. The Bigmouth Shiner is considered an important bait minnow in Colorado (Beckman 1953) and in Iowa, where it is an important forage fish (Harlan and Speaker 1951).

The subspecies of *N. dorsalis* are of scientific interest in that they represent geographically isolated populations that have been subjected to different environmental conditions.

Evaluation

The Bigmouth Shiner population in Canada is the most northern of the species. Favourable habitat in Canada is limited; thus, the species cannot be expected to expand significantly. The species should be considered rare in Canada.

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Literature Cited

- Adams, C. C., and T. L. Hankinson. 1928. The ecology and economics of Oneida Lake fish. *Rooseveltdt Wildlife Annual* 1: 235-548.
- Bailey, R. M., and M. O. Allum. 1962. Fishes of South Dakota. Museum of Zoology, University of Michigan. Miscellaneous Publication Number 19.
- Beckman, W. C. 1953. Guide to the fishes of Colorado. University of Colorado Museum, Colorado Game and Fish Department, U.S. Fish and Wildlife Service.
- Clady, M. D. 1976. Change in abundance of inshore fishes in Oneida Lake, 1916 to 1970. *New York Fish and Game Journal* 23(1): 73-81.
- Copes, F. A., and R. A. Tubb. 1966. Fishes of the Red River tributaries in North Dakota. Contributions by the Institute of Ecological Studies, University of North Dakota, Number 1: 1-26.
- Cross, F. B. 1967. Fishes of Kansas. University of Kansas, Museum of Natural History, Lawrence, Kansas. Miscellaneous Publication 45.
- Cross, F. B., and W. L. Minckley. 1958. New records of four fishes from Kansas. *Transactions of the Kansas Academy of Science* 61: 104-108.
- Eddy, S., and J. C. Underhill. 1943. Northern fishes: special reference to the Upper Mississippi Valley. University of Minnesota Press, Minneapolis, Minnesota.
- Fedoruk, A. N. 1970. First Canadian record of the Bigmouth Shiner, *Notropis dorsalis* (Agassiz). *Canadian Field-Naturalist* 84: 391-394.
- Gilbert, C. R. 1980. *Notropis dorsalis* (Agassiz), Bigmouth Shiner. Page 260 in *Atlas of North American freshwater fishes*. Edited by D. S. Lee, C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and R. J. Stouffer, Jr. North Carolina State Museum of Natural History, Raleigh, North Carolina. Biological Survey Publication Number 1980-12.
- Griswold, B. L. 1963. Food and growth of spottail shiners and other forage fishes of Clear Lake, Iowa. *Iowa Academy of Science* 70: 215-233.
- Hankinson, T. L. 1929. Fishes of North Dakota. *Papers of the Michigan Academy of Science, Arts and Letters* 10: 439-460.
- Hinks, D. 1943. The fishes of Manitoba. Manitoba Department of Mines and Natural Resources, Winnipeg, Manitoba.
- Hanson, W. D., and R. S. Campbell. 1963. The effects of pool size and beaver activity on distribution and abundance of warm water fishes in a northern Missouri stream. *American Midland Naturalist* 69(1): 136-149.
- Harlan, J. R., and E. B. Speaker. 1951. Iowa fish and fishing. Iowa State Conservation Commission, Des Moines, Iowa.
- Hubbs, C. 1941. On the relation of hydrological conditions to speciation in fishes. Pages 182-195 in *Symposium on hydrobiology*. University of Wisconsin Press, Madison, Wisconsin.
- Hubbs, C., and K. Lagler. 1958. Fishes of the Great Lakes Region. Cranbrook Institute of Science, Bloomfield Hills, Michigan.
- Hubbs, C., and B. Walker. 1942. Habitat and breeding behavior of the American cyprinid fish *Notropis longirostus*. *Copeia* 1942: 14-27.
- Johnson, M., and G. C. Becker. 1970. Annotated list of the fishes of Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 58: 265-300.
- Keeton, D. 1963. Growth of fishes in the Des Moines River, Iowa, with particular reference to water levels. Ph.D. thesis, Iowa State University of Science and Technology.
- Mayes, M. A. 1977. New species of *Gyrodactylus* and *Dactylogyrus* (Trematoda: Monogenea) from fishes of Nebraska. *Journal of Parasitology* 63(5): 805-809.
- Mendelson, J. 1975. Feeding relationship among species of *Notropis* (Pisces: Cyprinidae) in a Wisconsin stream. *Ecological Monographs* 45: 199-230.
- Metcalf, A. L. 1966. Fishes of the Kansas River system in relation to zoogeography of the Great Plains. University of Kansas Publications, Museum of Natural History 17(3): 23-189.
- Mills, P. A., C. H. Hocutt, and J. R. Stauffer. 1978. The preimpondment fish fauna of Big River (Meramec drainage, Missouri). *Transactions of the Mississippi Academy of Sciences* 12: 25-35.
- Moore, G. A. 1944. Notes on the early life history of *Notropis girardi*. *Copeia* 1944: 209-214.
- Pfleiger, W. L. 1971. A distributional study of Missouri fishes. University of Kansas Publications, Museum of Natural History 20(3): 225-570.
- Pfleiger, W. L. 1975. The fishes of Missouri. Missouri Department of Conservation. Western Publishing, Columbia, Missouri.
- Samuel, N., B. B. Nickol, and M. A. Mayes. 1976. Acanthocephala of Nebraska fishes. *American Midland Naturalist* 96(2): 391-406.
- Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
- Starrett, W. C. 1950a. Distribution of the fishes of Boone County, Iowa, with special reference to the minnows and darters. *American Midland Naturalist* 43: 112-127.
- Starrett, W. C. 1950b. Food relationships of the minnows of the Des Moines River, Iowa. *Ecology* 31: 216-233.

- Starrett, W. C.** 1951. Some factors affecting the abundance of minnows in Des Moines River, Iowa. *Ecology* 32: 13-27.
- Taylor, W. R.** 1954. Records of fishes in the John N. Lowe collections from the Upper Peninsula of Michigan. Miscellaneous Publications of the Museum of Zoology, University of Michigan, Number 87.

- Trautman, M. B.** 1957. The fishes of Ohio. Ohio State University Press, Columbus, Ohio.
- Trautman, M. B.** 1981. The fishes of Ohio. Second edition. Ohio State University Press, Columbus, Ohio.

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Status of the Pugnose Shiner, *Notropis anogenus*, in Canada*

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The Pugnose Shiner, *Notropis anogenus*, is rare in Canada and had been collected at only four Ontario localities prior to 1982: Rondeau Harbour, Long Point Bay and Point Pelee, in Lake Erie, and at the outlet of Lake Ontario near the Gananoque River. Searches at known Canadian localities in 1979 failed, but these fish are secretive and difficult to collect. In 1982, a new population was discovered north of previously known localities in the Ausable River and in 1983 another new population was located near Mitchell's Bay on Lake St. Clair. Small populations may still exist in other localities. Habitat destruction is believed to be a factor limiting populations in Ontario. The Pugnose Shiner is not specifically protected in Canada, although general protection is afforded through the fish habitat sections of the Fisheries Act. Populations, if they survive, in Rondeau Provincial Park and Point Pelee National Park would receive protection from major habitat disturbances.

Le méné camus, *Notropis anogenus*, est rare au Canada; en effet, sa présence n'a été signalée auparavant qu'à quatre endroits, tous en Ontario: à Rondeau Harbour, à la baie Long Point, à la Pointe Pelée, sur le lac Érié et à la sortie du lac Ontario près de la rivière Gananoque. Malgré les efforts déployés en 1979 aux emplacements déjà connu au Canada, aucun spécimen n'a été capturé; mais ces poissons sont réservés et rarement vus. En 1982, une nouvelle population a été découverte au nord des localités connu auparavant, dans la rivière Ausable et en 1983 une autre nouvelle population a été découverte aussi dans le voisinage de la baie Mitchell sur le lac Ste-Claire. Il est quand même possible que de petites populations existent encore. On croit que la destruction de l'habitat est un facteur limitatif aux populations en Ontario. Le méné camus ne bénéficie pas d'une protection particulière au Canada, mais il est visé de façon générale par les articles concernant l'habitat du poisson dans la Loi sur les pêcheries. Les populations du parc provincial Rondeau et du parc national de la Pointe Pelée, si elles existent encore, sont protégées contre toute perturbation importante de l'habitat.

Key Words: Pugnose Shiner, *Notropis anogenus*, cyprinids, rare fishes, Ontario, minnows.

The Pugnose Shiner, *Notropis anogenus*, is one of several cyprinids or minnows which are not important to the economy of Canadian waters because of their small size and restricted distribution.

The species is at the northern extent of its range in Canada. Pugnose Shiners (Figure 1) are a small (3.8–5.1 cm), fragile species of clean, well-vegetated lakes and low-gradient streams (Trautman 1957). They are usually silvery in colour with a straw-coloured tint to the back. There is a distinct lateral band extending from the caudal peduncle through the eye and around the snout. A small dark spot may be found at the base of the caudal fin (Scott and Crossman 1973).

Distribution

The range and distribution of the Pugnose Shiner were documented by Bailey (1959) and Gilbert (1980). Few range extensions have been added since the late 1940s; the present distribution of this species is

probably much reduced from that represented in Figure 2.

In Canada the Pugnose Shiner was previously reported from four regions in Ontario (Figure 3): at the outlet of Lake Ontario near the mouth of the Gananoque River, Leeds County (44°20'N, 76°10'W); in the western basin of Lake Erie at Rondeau Harbour, Kent County (42°17'N, 81°53'W); in ponds on the eastern side of Point Pelee, Essex County (42°00'N, 82°30'W); and on the east side of Long Point, Lake Erie (42°38'N, 80°25'W). In 1982, a new population was discovered in the old Ausable River channel, Lambton County (43°18'N, 81°47'W), in large numbers (Crossman, personal communication) and in 1983, collections were made near the town of Mitchell's Bay, Kent County, on the northern shore of St. Luke's Bay (42°26'N, 82°26'W).

Hubbs and Lagler (1947) described the range of this species as being restricted to the Great Lakes basin and the north-central United States. It has been recorded sporadically from the Red River basin of eastern North Dakota through the glacial lakes district of Minnesota, northern Iowa, Wisconsin, northern Illinois, Michigan, northern Indiana and

*Rare status approved and assigned by COSEWIC April 1985.



FIGURE 1. Pugnose Shiner, *Notropis anogenus* (drawing by C. H. Douglas; courtesy D. E. McAllister, National Museum of Natural Sciences).

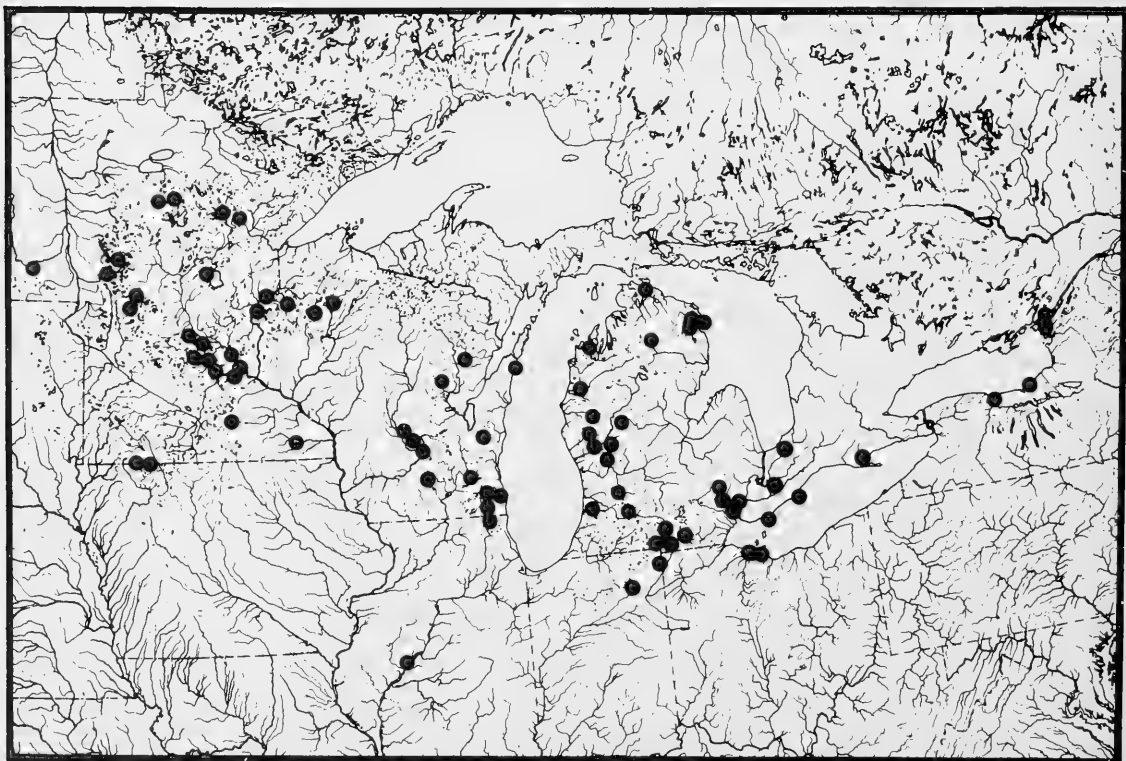


FIGURE 2. Distribution of *Notropis anogenus* (adapted from Bailey 1959).

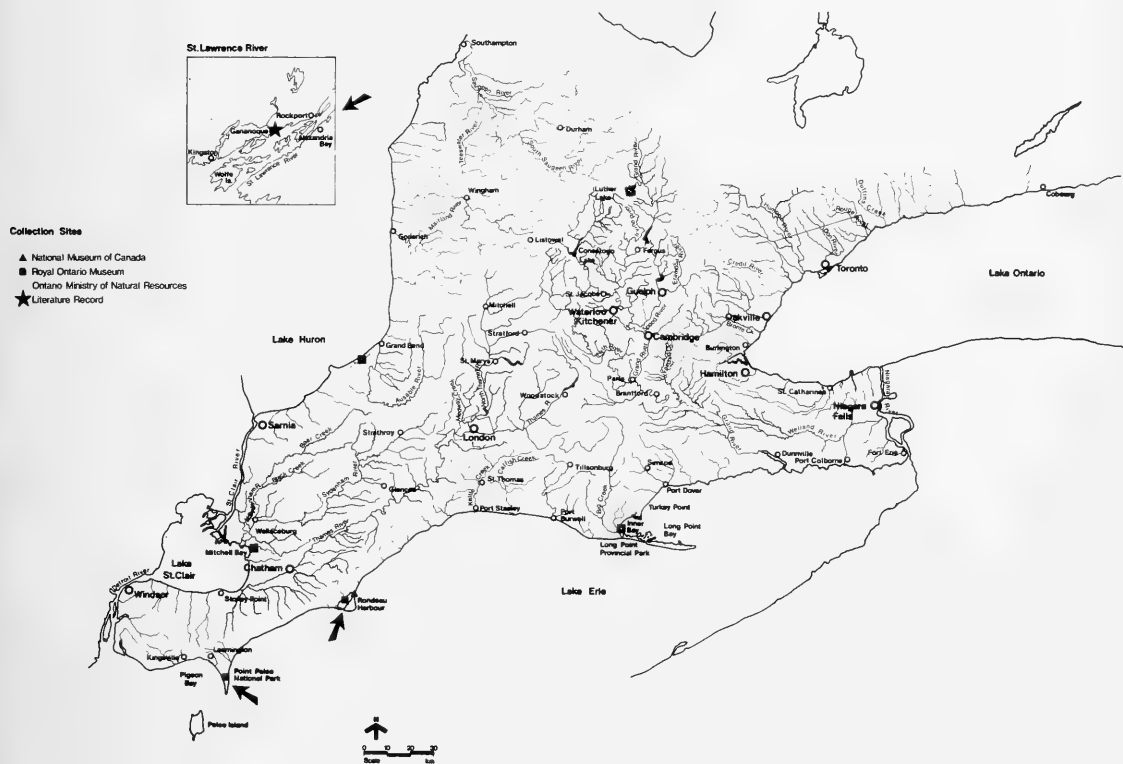


FIGURE 3. Collection records of the Pugnose Shiner in Ontario.

Ohio to the Lake Ontario and St. Lawrence River drainages of New York and Ontario. It is described by Bailey (1959) as one of the rarest cyprinids in the northern United States and southern Canada and as extirpated in some areas such as Ohio (M. Trautman, personal communication).

Protection

International

Protected as endangered in Wisconsin (Anonymous 1979).

National

Not specifically protected in Canada, although fish habitat sections of the Fisheries Act do afford general protection and populations, if they still survive, in Rondeau Provincial Park and Point Pelee National Park would receive protection from major habitat changes.

Population Size and Trends

The Pugnose Shiner was first reported in Canada in 1935 (Toner 1937). Subsequent collections were made during the early 1940s at Rondeau Bay, Long Point

Bay and Point Pelee. Since the 1940s, only three collections of Pugnose Shiners, made in 1968, 1982, and 1983, have been reported from Canadian waters.

During a 1979 survey, all known capture localities were sampled, but no Pugnose Shiners were captured (Parker and McKee 1980). However, a Royal Ontario Museum survey in 1982 did find Pugnose Shiners in large numbers in the Old Ausable River channel in Lambton County (Crossman, personal communication) and near Mitchell's Bay, Lake St. Clair, in 1983. It seems apparent, however, that other small populations of the Pugnose Shiner may still exist in Canada. Collection and identification of this species are hampered by its small size, restricted distribution and habitat selectivity. Although there is insufficient data to evaluate the population structure of this species in Canada, we believe that, if present in Canada, populations are extremely small and each population is localized.

Published information indicates that over its range this species is becoming increasingly rare. Scott and Crossman (1973) suggested that these fish may once have inhabited favourable habitats along the north shores of Lake Ontario and Lake Erie, but habitat

destruction is believed to have diminished its range greatly. McAllister and Gruchy (1977) and McAllister et al. (1985) considered the species endangered in Canada based on Scott and Crossman's (1973) assessment. Trautman (1957) stated that collections of this species in Ohio during the 1930s were probably from isolated populations which later died out as a result of increased turbidity in its habitat. It may be that similar long-term habitat destruction in Ontario waters has decreased the numbers of this species to very restricted habitats. However, these fish are secretive and rarely seen and may have been overlooked in past studies as indicated by the 1982 and 1983 findings of the Royal Ontario Museum.

Habitat

In Canada, the Pugnose Shiner has been recorded from sheltered inshore ponds and protected bays proximal to large water bodies. Substrates at Point Pelee, Mitchell's Bay and Gananoque were usually composed of sand and detritus, but in Rondeau Harbour the bottom substrates were predominantly clay. All localities where the Pugnose Shiner has been captured were heavily vegetated: both emergent and submergent aquatic macrophytes were present. Turbidity and siltation were minimal at Point Pelee and Gananoque (Secchi disc approximately 1.5 m); however, at Rondeau Harbour turbidity was much higher (Secchi disc approximately 0.3 m). During sampling in August, water temperatures ranged from 15 to 18°C and dissolved oxygen ranged from 9 to 11 mg/L in Rondeau Harbour and at Point Pelee (see Parker and McKee 1980). June water temperatures in the Ausable River ranged from 20 to 21°C as did July temperatures in the Mitchell's Bay collections (Crossman, personal communication).

Trautman (1957) suggested that this species is usually found in clear, well-vegetated lakes and low-gradient streams with sand, mud, and detrital bottoms. Of the three known capture sites investigated during Parker and McKee's (1980) study, Point Pelee appeared to provide the most favourable habitat for the continued existence of the Pugnose Shiner in Canada.

General Biology

Spawning is thought to occur in late spring in Ontario waters. A female collected in mid-June 1941 at Point Pelee contained a few large eggs, suggesting that it was partly spent and that spawning was in progress at that time (Scott and Crossman 1973). Females full of eggs were taken in May and June in Illinois (Forbes and Richardson 1920).

The feeding habits of the Pugnose Shiner in Canada are unknown, and specimens are unavailable for

dissection to determine stomach contents. Scott and Crossman (1973) suggested that its extremely small mouth probably restricts its diet to minute plants and animals.

Little has been published on the age and growth of this species. Trautman (1957) stated that adults ranged between 33 and 48 mm in length and Carlander (1969) gave the maximum length of this species as 56 mm total length. Specimens from Ontario waters ranged in length from 38 to 51 mm total length, and were assumed to be adults.

Two species of Protozoa, *Henneguya brachyura* and *Myxophus aureatus*, are the only parasites Hoffman (1967) listed for this species. Parasites have not been noted for Canadian specimens.

The Pugnose Shiner probably falls prey to several species of piscivorous fish. Examination of the stomach contents of possible predators, especially from Point Pelee National Park, may prove beneficial in obtaining information on this species in Canada.

Limiting Factors

According to Trautman (1957), Bailey (1959), and Scott and Crossman (1973), populations of this species have been reduced or extirpated in the United States and perhaps in some locations in Ontario due to habitat modifications including increased turbidity and reduction of vegetation.

Special Significance of the Species

Canadian populations are the northernmost of this rare species which is disappearing even in the United States.

Evaluation

There is insufficient evidence to conclude that reproducing populations of Pugnose Shiners are extirpated or endangered in Canada. The Pugnose Shiner occurs in Canada at the northern fringe of its North American range. It has been suggested that this species is naturally rare throughout its North American range. Canadian records suggest that populations are small and geographically isolated.

Available evidence suggests that the amount of available habitat may have been diminished in quality and quantity due to a general decline in water quality and an increase in lakeshore development. Due to the habitat requirements of the species, it is rarely seen or collected. Had significant numbers been seen at some time in the past, then the low numbers seen today might suggest that they are threatened or endangered. This is not the case. The new records for 1982 and 1983 suggest researchers have not looked in the right places and renewed efforts should be made to locate possible populations in known localities before any status other than rare is considered.

Acknowledgments

This paper is based on a more detailed discussion of the species in Parker and McKee (1980). Funding for the study and subsequent reports were under the auspices of Supply and Services Canada, the Department of Fisheries and Oceans and the National Museum of Canada under contract 15279-00146.

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Literature Cited

- Bailey, R. M.** 1959. Distribution of the American cyprinid fish *Notropis anogenus*. *Copeia* 1959(2): 119–123.
- Carlander, K. D.** 1969. Handbook of freshwater fishery biology. Volume 1. Life history data on freshwater fishes of the United States and Canada, exclusive of the Perciformes. Iowa State University Press, Ames, Iowa.
- Forbes, S. A., and R. S. Richardson.** 1920. The fishes of Illinois. Illinois State Natural History Survey Division, Urbana, Illinois.
- Hoffman, G. L.** 1967. Parasites of North American freshwater fishes. University of California Press, Los Angeles, California.
- Hubbs, C. L., and K. F. Lagler.** 1947. Fishes of the Great Lakes Region. Cranbrook Institute of Science Bulletin 26.
- Gilbert, C. R.** 1980. Pugnose Shiner (*Notropis anogenus*). Page 227 in Atlas of North American Freshwater fishes. Edited by D. S. Lee, C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and R. J. Stouffer, Jr. North Carolina State Museum of Natural History, Raleigh, North Carolina. Biology Survey Publication Number 1980–12.
- McAllister, D. E., and C. G. Gruchy.** 1977. Status and habitat of Canadian fishes in 1976. Pages 151–157 in Canada's threatened species and habitats. Edited by T. Mosquin and C. Suchal. Canadian Nature Federation Special Publication 6.
- McAllister, D. E., B. J. Parker, and P. M. McKee.** 1985. Rare, endangered and extinct fishes in Canada. Syllogeus (National Museums of Canada) Number 54.
- Miller, R. R.** 1972. Threatened freshwater fishes of the United States. Transactions of the American Fisheries Society 101(2): 239–252.
- Parker, S., and P. McKee.** 1980. Rare, threatened and endangered fishes in southern Ontario: Status reports. A report for Department of Supply and Services, Department of Fisheries and Oceans, and National Museum of Natural Sciences. Beak Consultants Limited, Mississauga, Ontario.
- Scott, W. B., and E. J. Crossman.** 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
- Toner, G. C.** 1937. Preliminary studies of the fish of eastern Ontario. Bulletin of Eastern Ontario Fish and Game Protection Association Supplement 2: 1–24.
- Trautman, M. B.** 1957. The fishes of Ohio with illustrated keys. Ohio State University Press, Columbus, Ohio.

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Status of the Pugnose Minnow, *Notropis emiliae*, in Canada*

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The Pugnose Minnow, *Notropis emiliae*, is rare in Canada. It has been reported from only 10 localities in southern Ontario where it attains the northeastern limit of its range. Siltation is the most likely factor affecting its distribution and survival. The Pugnose Minnow is not specifically protected in Canada, although general protection is afforded through the fish habitat sections of the Fisheries Act.

Le petit-bec, *Notropis emiliae*, est rare au Canada. Il n'a été signalé qu'en 10 endroits dans le sud de l'Ontario, la limite nord-est de son aire de répartition. L'envasement est probablement le facteur qui influe le plus sur sa répartition et sa survie. Le petit-bec n'est pas protégé de façon particulière au Canada, quoique l'article sur la protection de l'habitat du poisson dans la Loi sur les pêcheries le protège de façon générale.

Key Words: Pugnose Minnow, *Notropis emiliae*, cyprinids, Ontario, rare species.

The Pugnose Minnow, *Notropis emiliae*, is a small cyprinid (Figure 1) with a very restricted Canadian distribution (Figure 2). Information on this species in Canada is almost as rare as the fish itself.

These are small minnows averaging 5 cm in length which prefer slow waters with plenty of aquatic vegetation (Scott and Crossman 1973). They are usually silvery in colour with yellowish or olive overtones and have a distinct lateral band which goes past the eye to the end of the snout. Nuptial tubercles may be present around the mouth of breeding males (Scott and Crossman 1973).

Distribution

The Pugnose Minnow is found primarily in the Gulf states and the Mississippi River basin in central North America. In Canada this species occurs in the Lake St. Clair and possibly in the Lake Erie drainages of southwestern Ontario (Figure 2). Populations in Canada are separated from those in the United States by approximately 200 km. It is known in Ontario from 10 localities (Figure 3), which are listed in more detail by Parker and McKee (1980).

Protection

International: variably listed as rare, threatened, or extirpated in Ohio (Trautman 1957; Van Meter and Trautman 1970) and as endangered in Missouri (Miller 1972).

National: not protected in Canada, although fish habitat sections of the Fisheries Act do offer general protection.

Population Size and Trends

The population structure of the Pugnose Minnow in Canadian waters is not fully known. On the basis of the number of confirmed captures it is suspected that the population of the Pugnose Minnow in the Lake St. Clair drainage is quite small.

Intensive efforts to capture Pugnose Minnows during the 1979 survey of Parker and McKee (1980) produced only eight specimens. Catch-per-unit-effort values for the North Sydenham River were low and ranged from 0 to 3.3 specimens per 100 square meters of area seined.

The known range of the Pugnose Minnow in the Sydenham River system was extended during the 1979 survey, although it is unlikely that this represents an expansion of the population. It is possible that the rarity of the Pugnose Minnow and its confinement to a restricted habitat has permitted small populations to exist undetected at these locations until recently. The largest collection of Pugnose Minnows in the Thames River watershed produced seven specimens in 1968 (ROM 26480).

Collections from the Thames River and tributary streams of Lake Erie suggest that disjunct populations of Pugnose Minnows are extant in southwestern Ontario and that this species may once have been more widely distributed.

McAllister and Gruchy (1977) thought the species to be endangered in Canada. However, the recent records from the Sydenham River system exceed the

*Rare status approved and assigned by COSEWIC 2 April 1985.

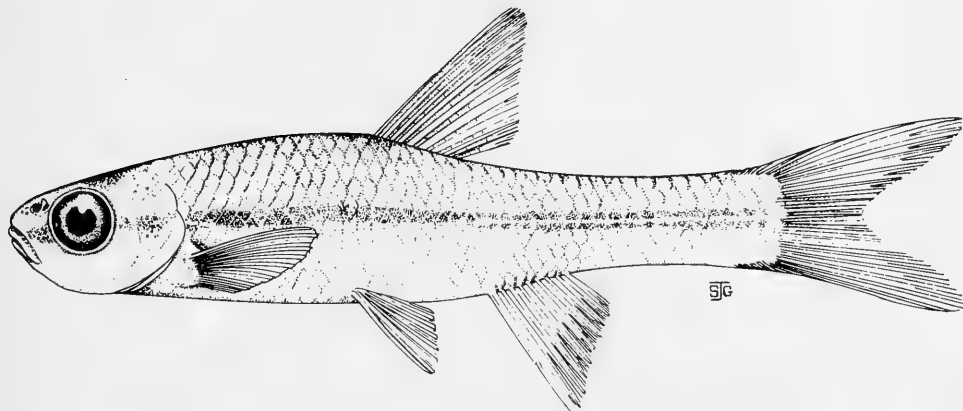


FIGURE 1. Pugnose Minnow, *Notropis emiliae* (drawing by Sally J. Gadd; courtesy D. E. McAllister, National Museum of Natural Sciences).

total of all previous knowledge of these fish, which are abundant nowhere and barely get into Ontario.

Habitat

In Ontario, the Pugnose Minnow is found in low gradient streams, rivers, and lakes. Average gradients at capture sites in the Sydenham River watershed range from less than 0.02 m/km. Specimens were taken in pond-like, weedy embayments and along river edges. Capture sites in Mitchell's Bay had soft clay and silt substrates.

Aquatic macrophytes were always present at capture sites. Heavy growths of spatterdock (*Nuphar* sp.) were noted at several capture localities. Pugnose Minnows were captured in the North Sydenham River in water 0.5 to 1.5 m deep by encircling clumps of weeds with a seine net.

High levels of suspended solids were evident at all capture locations during the 1979 survey of Parker and McKee (1980); secchi disc transparency of 10 cm was typical in most of the North Sydenham River. Water transparency was higher in Mitchell Bay. Pugnose Minnows were caught in September when water temperatures ranged from 17.5 to 19°C and dissolved oxygen concentrations were about 7 mg/L.

Trautman (1957) stated that the Pugnose Minnow prefers sluggish, clear weedy waters, and believed that populations in turbid waters where siltation has resulted in the elimination of rooted aquatic plants would be eliminated in a matter of years. The high turbidity at capture sites during the 1979 survey of Parker and McKee (1980) suggests that the North Sydenham River system may provide only marginal

habitat for this species. Mitchell Bay may provide a more favourable habitat.

General Biology

Little information has been published on the biology of this species. Scales from several Ontario specimens were examined following methods outlined by Lagler (1947). Each scale appeared to have distinct annuli in the lateral fields; however, validation of the scale method of age determination in this species would require a larger sample. Maximum age was estimated at three years.

Ranges of lengths and preserved weights for one, two and three-year-old specimens captured in September are as follows: age 1, 2.9 to 3.2 cm standard length, 0.24 to 0.29 g weight; age 2, 3.4 to 3.7 cm standard length, 0.57 to 0.73 g weight; age 3, 4.6 cm standard length, 1.19 g weight.

In Ohio, young-of-the-year are 2.5 to 4.3 cm long, one-year-old fish are 3.3 to 5.1 cm long, and adults are usually 3.8 to 5.8 cm long, with a maximum recorded length of 6.4 cm (Trautman 1957).

Data on reproduction in this species are limited. Gilbert and Bailey (1972) stated that in Florida males are in spawning condition from March to September and gravid females were captured from January to September and gravid females were captured from January to September. Gilbert and Bailey (1972) also mentioned that specimens in spawning condition were taken in late May in Arkansas. Forbes and Richardson (1909) collected gravid females and tuberculate males in mid-June in Illinois. It is



FIGURE 2. Canadian distribution of the Pugnose Minnow.

suspected that populations in Ontario spawn in late spring or early summer.

The feeding habits of Pugnose Minnows have been studied by Gilbert and Bailey (1972) from Florida specimens. Chironomid larvae, filamentous algae, copepods, cladocerans, hydrachnids, and minute amounts of larval fish and fish eggs were identified from stomach contents. Of four Ontario specimens of Pugnose Minnows examined, two had empty foreguts, one contained unidentifiable material and one contained 30 percent adult Diptera and 10 percent larval Trichoptera by volume. Scott and Crossman (1973) believe that the strongly upturned mouth of the

Pugnose Minnow suggests a mid-water or surface feeding habit.

Predation on Pugnose Minnows by other fishes has not been described. Piscivorous species captured in the same locations as Pugnose Minnows in 1979 include Northern Pike (*Esox lucius*), White Crappie (*Pomoxis annularis*), Rock Bass (*Ambloplites rupestris*), and Largemouth Bass (*Micropterus salmoides*).

A low-level infestation of "black spot" (*Neascus*) was noted on one Pugnose Minnow taken during the 1979 survey of Parker and McKee (1980). Bangham and Hunter (1939) reported that of 10 specimens



FIGURE 3. Collection records of *Notropis emiliae* in Ontario.

examined from Lake Erie, two were infected with trematodes and larval or immature cestodes. Hoffman (1967) also listed trematodes as parasites of the Pugnose Minnow.

Limiting Factors

The turbid habitats where Pugnose Minnows were captured during the 1979 survey of Parker and McKee (1980) differ from the preferred clear-water habitat described by Trautman (1957), Gilbert and Bailey (1972), and Scott and Crossman (1973). This suggests that the Sydenham River watershed provides only marginal habitat. Trautman (1957) reported that this species was probably common in Ohio prior to 1930 in clear, weedy, quiet waters. Urbanization and agricultural practices subsequently led to the siltation of these habitats and eventual extirpation of the Pugnose Minnow from many parts of its range. The siltation of streams in southwestern Ontario may be similarly detrimental to Canadian populations of the species.

Special Significance of the Species

The Ontario populations are the only representatives of this species and the subgenus *Opsopoedus* in Canada. It is apparently sensitive to turbidity, and so it may have some importance as an environmental indicator in the Lake St. Clair drainage.

Evaluation

A small population of Pugnose Minnows is present in the North Sydenham River and in Mitchell Bay. Whether the specimens collected are representative of one or more populations is not known. There is insufficient information to evaluate the structure of possible populations in the Thames River or in Lake Erie tributaries; however, these populations are likely small and isolated.

Man-induced siltation of preferred clear-water habitats has led to the extirpation of this species within other areas of its North American range. The North Sydenham River provides marginally suitable

habitat for this species; man-induced siltation has reduced the quantity of available, suitable habitat.

Pugnose Minnow populations in Canada are situated at the northeastern edge of the North American range. Because of this limited distribution and number in Canada the Pugnose Minnow should be considered a rare species in Canadian waters.

Acknowledgments

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Literature Cited

- Bangham, R. V., and G. W. Hunter.** 1939. Studies on fish parasites of Lake Erie. Distribution studies. *Zoologica* 24(4); part. 27: 385-448.
- Forbes, S. A., and R. E. Richardson.** 1909. The fishes of Illinois. *Natural History Survey of Illinois* 3: 1-357.
- Gilbert, C. R., and R. M. Bailey.** 1972. Systematics and zoogeography of the American cyprinid fish *Notropis (Opsopoeodus) emiliae*. *Occasional Papers of the Museum of Zoology, University of Michigan* (664): 1-35.
- Hoffman, G. L.** 1967. *Parasites of North American freshwater fishes*. University of California Press, Los Angeles, California.

- Lagler, K. F.** 1947. *Lepidological studies. 1. Scale characters of the families of Great Lakes fishes*. Transactions of the American Microscopic Society 66(2): 149-171.
- McAllister, D. E., and C. G. Gruchy.** 1977. Status and habitat of Canadian fishes in 1976. Pages 151-157 in *Canada's threatened species and habitats. Edited by T. Mosquin and C. Suchal*. Canadian Nature Federation Special Publication 6.
- Miller, R. R.** 1972. Threatened freshwater fishes of the United States. *Transactions of the American Fisheries Society* 101(2): 239-252.
- Parker, B., and P. McKee.** 1980. Rare, threatened and endangered fishes in southern Ontario: Status reports. A report for the Department of Supply and Services, Department of Fisheries and Oceans, and National Museum of Natural Sciences. Beak Consultants Limited, Mississauga, Ontario.
- Scott, W. B., and E. J. Crossman.** 1973. *Freshwater fishes of Canada*. Fisheries Research Board of Canada Bulletin 184.
- Trautman, M. B.** 1957. *The fishes of Ohio with illustrated keys*. Ohio State University Press, Columbus, Ohio.
- Van Meter, H. O., and M. B. Trautman.** 1970. An annotated list of the fishes of Lake Erie and its tributary waters exclusive of the Detroit River. *Ohio Journal of Science* 70: 65-73.

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Status of the Central Stoneroller, *Campostoma anomalum*, in Canada*

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McAllister, D. E. 1987. Status of the Central Stoneroller, *Campostoma anomalum*, in Canada. Canadian Field-Naturalist 101(2): 213–218.

Aside from two records in the upper Niagara drainage, the Central Stoneroller (*Campostoma anomalum*) is restricted to a small area in the Thames River drainage upstream of London. This range is within a rectangle 25 by 45 km. The Thames River drainage population is isolated from the rather widespread populations in the United States. There are no population estimates for Canadian occurrences. Available evidence suggests that the small Canadian populations are expanding in range. It is unknown whether this is a long-term trend, whether the expansion is cyclic, or the result of one or two years' reproductive success. This species is one of the few periphyton feeders in Canadian waters. It is the sole representative of the genus in Canada and it has several adaptations to herbivory: cartilaginous lips, ventral mouth, and an elongate intestine wound spirally about the gas bladder. While the Canadian populations are in no known immediate danger, their status, given their very small range and sensitivity to aquatic pollution, should be carefully monitored. Studies are needed to determine their populations levels, and nursery and overwintering requirements. Dam construction in the Thames River should take into account the presence of this species which does not thrive in impoundments. The taxonomy of the Canadian population requires study to determine which subspecies inhabits our waters.

Le roule-caillou (*Campostoma anomalum*) dont on a signalé à deux reprises la présence dans le bassin du cours supérieur de la rivière Niagara, est confiné à une petite partie du réseau hydrographique de la rivière Thames, en amont de London. Son aire de répartition s'étend en deçà d'un rectangle de 25 km sur 45 km. La population de réseau hydrographique de la Thames est isolée des populations des États-Unis, dont l'aire de répartition est passablement étendue. Il n'y a pas d'estimations de populations pour la population canadienne: les données disponibles portent à croire que son aire est en train de s'étendre. On ignore si les données portent à croire que son aire est en train de s'étendre. On ignore si cette tendance se maintiendra à long terme, si elle s'inscrit dans un cycle particulier ou si elle est due à une ou deux bonnes années de reproduction. Il s'agit d'une des rares espèces des eaux canadiennes à se nourrir de périphyton. Le roule-caillou est le seul représentant de son genre au Canada. Il présente plusieurs caractéristiques des herbivores: lèvres cartilagineuses, bouche inférieure, intestin allongé et enroulé autour de la vessie natatoire. Bien que les populations canadiennes ne semblent pas en danger pour l'instant, on devrait les surveiller étroitement vu leur répartition restreinte et leur sensibilité à la pollution aquatique. Il faudrait entreprendre des études pour déterminer les niveaux des populations, ainsi que leurs besoins pour ce qui est des aires de croissance et d'hivernage. Avant d'entreprendre la construction d'un barrage sur la rivière Thames, on devrait tenir compte de la présence de cette espèce, qui ne se développe pas bien dans les bassins de retenue. La classification de la population canadienne requiert la réalisation d'études qui permettront de déterminer quelle sous-espèce habite nos cours d'eau.

Key Words: Central Stoneroller, *Campostoma anomalum*, cyprinids, rare species, minnows, Ontario.

The Central Stoneroller, *Campostoma anomalum*, is a light brown coloured member of the minnow family. The fish (Figure 1) is characterized by horny sheaths on the upper and lower jaws and an intestine coiled about the gas bladder. The species is one of the larger minnows, maximum length up to 28.7 cm (Lennon and Parker 1960), and a maximum age of six years. The species resembles the River Chub, *Nocomis micropogon*, and smaller White Suckers, *Catostomus commersonii*. *Campostoma anomalum* is the only Canadian representative of the genus and it was unknown in Canada prior to 1972 (Gruchy et al.

1973). It is one of the few fishes which feed on periphyton.

Distribution

The Central Stoneroller occurs in streams throughout much of the eastern and central United States (see Burr 1980). In the west, scattered populations occur in the Dakotas, including sections of the Red River watershed in the Hudson Bay basin. Scattered populations also occur in the Mississippi River basin in Wyoming, Colorado, and New Mexico. In the south the stoneroller is found in the Rio Grande drainage in New Mexico, Texas, and Mexico, and in the headwaters of many rivers along the Gulf slope from Texas to Georgia. The eastern limit of the range of the stoneroller extends to the Atlantic drainage along the eastern limit of the Appalachian highlands

*Rare status approved and assigned by COSEWIC April 1985.

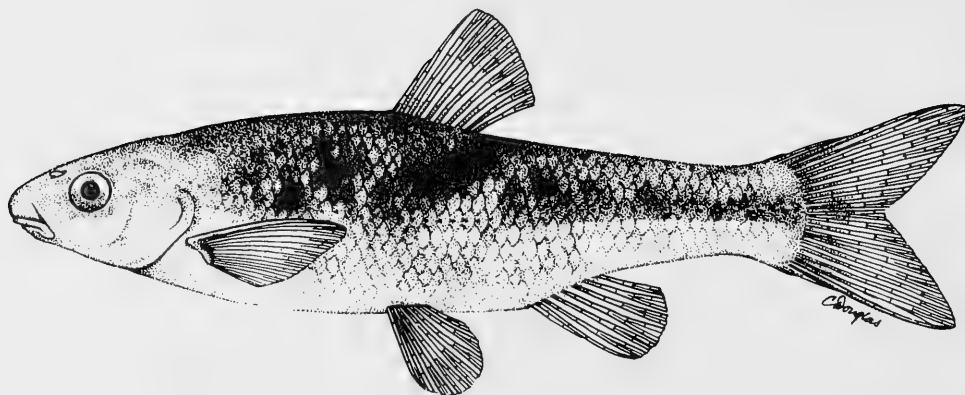


FIGURE 1. Central Stoneroller, *Campostoma anomalum* (drawing by C. H. Douglas, National Museum of Natural Sciences).

from Georgia to New York. In the northern part of its range, this species occurs in a few tributaries of Lake Ontario in New York and Ontario, in the Lake Erie and Mississippi River drainages of Ohio, in the Lake St. Clair drainage of Ontario, and in the Mississippi River basin of Wisconsin and Minnesota.

In Ontario, the stoneroller is found primarily in the Thames River watershed. A small number of specimens have also been reported from the Niagara River (Figure 2). In the Thames River watershed the stoneroller occurs in the North Thames River from Mitchell, Middlesex County ($43^{\circ}27'30''\text{N}$, $81^{\circ}12'20''\text{W}$), to London, Middlesex County ($42^{\circ}58'45''\text{N}$, $81^{\circ}58'45''\text{W}$), and in the Thames River from Dorchester, Middlesex County ($42^{\circ}59'13''\text{N}$, $81^{\circ}03'58''\text{W}$), to London. Collections have also been made from Whirl Creek, Fish Creek, Nineteen Creek, Otter Creek, Gregory Creek, Wye Creek, Stoney Creek, Medway Creek, and the Avon River which flow into the North Thames River, and from Pottersburg Creek and Waubuno Creek, which flow into the Thames River. Stonerollers have also been collected in Ontario from the Niagara River at the mouth of Frenchman's Creek near Fort Erie, Welland County ($42^{\circ}56'42''\text{N}$, $78^{\circ}55'30''\text{W}$), and from the Niagara River at Fort Erie ($42^{\circ}56'22''\text{N}$, $78^{\circ}55'05''\text{W}$).

The stoneroller's Ontario range in the Thames River watershed fits within a rectangle 25 by 45 km and is located over 125 km from American populations in Michigan. Ontario specimens from the Niagara River are closer to American populations in New York than to the Thames River populations, which are over 160 km away. Thus the Thames River populations are disjunct from both Niagara and American St. Clair basin populations.

Protection

The Ontario populations are under no special legal or other form of protection except for the general protection of habitat sections of the Fisheries Act.

Population Size and Trend

The population size of stonerollers in Ontario has not been estimated. However, the range of the stoneroller population in the North Thames River appears to have expanded considerably over the past seven years. The 1972 survey of Gruchy et al. (1973) covered many of the areas where this species is now abundant, yet specimens were captured by Gruchy only in Fish Creek and its tributary, Nineteen Creek (Gruchy, personal communication). In surveys carried out by the Ontario Ministry of Natural Resources up to 1975, stonerollers were captured over a wider area but no specimens were taken north of St. Marys in the North Thames River. The apparent distribution of this species in 1979 in the North Thames River, as documented in this study, was considerably more extensive than indicated by earlier Ontario Ministry of Natural Resources surveys, suggesting continued expansion of this population.

Although this range expansion is encouraging, too much confidence should not be placed in maintenance or continued expansion of these populations. The cause of the expansion is as yet unknown. It is possible that expansion is due to temporary amelioration of habitat due to an upswing in, for example, climatic conditions. Further observations in the summer of 1982 by Thomas A. Edge suggested that the species was maintaining itself.



FIGURE 2. Collection records of the Central Stoneroller in Ontario (adapted from Parker and McKee 1980).

Habitat

Suitable habitat is widespread in the central United States, but judging by the restricted distribution in Canada and in Michigan, the species is at the northern limit of its range and some factors, perhaps temperature, are limiting its occurrence in Ontario. Judging merely by its distribution in Ontario, suitable habitat is localized. Trends in quality and quantity of critical habitat are unknown, although the stoneroller's recent expansion suggests that suitable habitat may be increasing. This may be due to temporary factors such as a warming trend in the climatic cycle, or possibly to man-made influences such as increased periphyton. On the other hand, the spread might have resulted simply from two or three years' successful spawnings.

In the Thames drainage, *C. anomalum* occurs in both pools and riffles of small to medium-sized streams. Stream widths at capture sites ranged from 2 to 35 m. In riffles, stonerollers were often captured in clumps of *Potamogeton pectinatus* where water velocities were reduced. Large stonerollers (5 cm standard length) were usually found in relatively deep

riffles (to 0.5 m) and pools (to 1.5 m), while smaller fish were more common in shallower pools and riffles. Lennon and Parker (1960) also noted that this species normally occurs in creeks and small rivers.

Over the range of *C. anomalum* in the Thames drainage, stream gradients average 1.0 to 3.7 m/km. Downstream from London where the stoneroller is absent, gradients drop abruptly to an average of 0.5 m/km. Elsewhere this species is abundant in streams having relatively high gradients but is generally absent from low-gradient streams (Lennon and Parker 1960).

Campostoma anomalum is apparently tolerant of some variation in water quality. In mid-September this species was found at temperatures of 17.5–25°C and oxygen levels of 3–17 mg/L. During late spring, temperatures of 14–25°C and dissolved oxygen concentrations of 10–16 mg/L were observed. Diurnal fluctuations of 3–25 mg/L oxygen were common during low flow in the North Thames (Wong and Clark 1976). Turbidity levels also fluctuate considerably in this system, largely owing to intensive agriculture and erosion. While the stoneroller prefers

clear water (Hubbs and Lagler 1947; Trautman 1957; Burr 1980) and is not noted for its ability to withstand oxygen depletion or polluted or silted habitats, Miller (1964) and Burr (1980) indicated that stonerollers are relatively tolerant of water quality variations.

There are no areas of the Ontario range which provide specific habitat protection. While the Ontario population is apparently expanding, the cause of this is unknown and the localized nature of its Ontario distribution means it is exposed to pesticide spills and other environmental disasters. Acquisition of an entire stream or two in an area little-exposed to human influence might offer the best long-term protection for the species.

Gravel beds are required for spawning; siltation would be detrimental. Filamentous algae or periphyton are important food items in the diet. Factors which reduce or eliminate these foods would threaten population survival. Threats might include herbicides, high turbidity which would block light, and channelization.

General Biology

Reproductive Capability

Females over 7 cm in standard length and males over 7.5 cm are mature, suggesting that maturity is reached during the second or third year in Ontario, as in Michigan (Hubbs and Cooper 1936). In North Carolina most stonerollers mature during their third or fourth year and females usually mature before males (Lennon and Parker 1960).

Males and females in spawning condition were captured in small tributaries of the North Thames River in mid-May at water temperatures of 14 to 16°C. Specimens were all spawned out in creeks where the water temperature averaged 21°C in late May. Miller (1964) and Smith (1935) reported a wider temperature range for spawning stonerollers in the United States: Miller stated that spawning begins in mid-April and continues until early June over a temperature range of 14 to 24°C in New York, and Smith suggested an even wider spawning temperature range of 12 to 27°C for Illinois populations.

Few specimens were captured in the main stream of the North Thames River during the spring survey. Schools of spawning stonerollers were captured in riffles and eddies of small tributary creeks (usually less than 3 m in width) with clean gravel bottoms. The water velocity in these creeks ranged from 0.30 to 0.45 metres/second. Dissolved oxygen levels averaged 10 to 16 mg/L.

The spawning process has been described in detail by Langlois (1937) and Miller (1962, 1964). Males build nests of gravel in both slow water and riffle areas. Males are territorial and guard the nests. Eggs

are covered with sand and fine gravel during and after the spawning act. Stonerollers will also use nests of other cyprinids, while other species may spawn over stoneroller nests. Increase in the Ontario range suggests that, at present, reproduction is replacing mortality.

Little is known of the species movement in the fall or winter, but in spring, adults move out of rivers into streams usually less than 3 metres wide. There they congregate on gravelled areas in both slow water and riffles. The species appears to be relatively tolerant of human disturbance as long as the special food and spawning requirements are met.

Age

Twenty-five stonerollers, including individuals from all length classes collected during the 1979 survey, were aged by the scale method described by Hubbs and Cooper (1936) and Lennon and Parker (1960). In September, young-of-the-year ranged from 23 to 39 mm standard length, and from 0.2 to 1.0 grams (preserved weight), 1+ fish ranged from 41 to 62 mm and from 1.3 to 4.4 grams, 2+ fish ranged from 55 to 87 mm in length and from 3.7 to 15.1 grams, 3+ fish ranged from 82 to 99 mm and from 15.2 to 22.0 grams. No specimens appeared to be older than 3+ years, suggesting that stonerollers have a life span of three to four years in the Thames River watershed.

The age-length relationships determined for Thames River stonerollers are similar to those given by Lewis and Elder (1953) and Gunning and Lewis (1956) for Illinois populations, and by Carlander (1969) for Ohio populations. In the northern United States this species has a maximum age of about 3+ years and maximum total lengths are reported to be 143 mm in Illinois, 152 mm in Michigan, and 178 mm in Ohio (Gunning and Lewis 1956; Hubbs and Cooper 1936; Trautman 1957, respectively). Lennon and Parker (1960) found a maximum age of six years and a maximum length of 287 mm for stonerollers in North Carolina.

Food

Lennon and Parker (1960) reported that stonerollers feed mostly on periphyton in North Carolina. Carlander (1969) reported that this species feeds primarily on algae but also consumes some chironomid larvae. Trautman (1957) reported that stonerollers consume "micro-plants and small animals". This species was observed scouring the bottom over the spawning areas of Rosyface Shiners, *Notropis rubellus*, (Pfeiffer 1955) and Black Redhorse, *Moxostoma duquesnei*, (Bowman 1959), but egg predation was not verified in either case.

The subterminal mouth, cartilaginous lips, elongate intestine and black peritoneum are all probably

morphological adaptations that aid in feeding on, and digestion of, periphyton.

Limiting Factors

Limiting factors for this species in Ontario are unknown. However, potential limiting factors are the area of silt-free spawning beds and the amount of suitable algae for food. In Ohio the species is limited by the abundance of micro-plants and small animals upon which they feed, by oxygen depletion, and by pollutants or clay siltation which greatly decrease the amount of food. The impoundment of streams and creation of reservoirs appear to limit the distribution of the stoneroller in the Thames drainage. Despite intensive seining, no specimens were taken upstream of dams on Medway Creek and on the North Thames River near Mitchell. Nor has it been reported in Fanshawe Lake, a North Thames reservoir, although high densities occur upstream and downstream of the lake.

Predation on stonerollers by other fish in the Thames River watershed was not observed. Smallmouth Bass, *Micropterus dolomieu*, and Rock Bass, *Ambloplites rupestris*, are largely piscivorous and are common in streams inhabited by stonerollers. Due to the abundance of stonerollers in much of the upper Thames River watershed, this species likely accounts for a significant portion of the diet of piscivorous species. According to Lennon and Parker (1960), centrarchids appear to control the number of stonerollers by predation. There is no evidence, however, to suggest that predation is a limiting factor at present in Ontario.

Most stonerollers collected in Ontario harboured the "black-spot" trematode, *Uvulifer*, and infestations were heavy in some specimens. Berra and Au (1978) found that black-spot infestations are often heavier in this species than in other cyprinids. Hoffman (1967) provided a check list of stoneroller parasites.

Special Significance of the Species

Lennon and Parker (1960) summarized the importance of stonerollers to man. This species is locally favoured both as food fish and as a bait fish in the United States. Fishermen use bits of worms on small hooks to catch these fish when the latter congregate over spawning beds. This species is reputed to be one of the best bait minnows for bass, pickerel, and catfish. It can be raised in bait production ponds and makes an interesting aquarium fish. Stonerollers have been known to limit the production of Rainbow Trout, *Salvelinus gairdneri*, by destroying trout redds during spawning.

This species is the only representative of its genus in Canada and has a number of unique morphological

characters such as a gut spirally wound around its gas bladder and cartilaginous sheaths on the lips. Ecologically it is an important species because few other Canadian species feed on filamentous algae or on the micro-plants and animals found in sand, muck, or periphyton.

Evaluation

Since this species has a very small range in Canada, and the Thames River population is isolated from other populations, and because of its unique feeding niche, the Central Stoneroller deserves some level of protection in Canada. Whereas the population is not presently diminishing and is not under an immediate threat, the species should be considered rare in Canada.

Acknowledgments

C. G. Gruchy first discovered this species in Canada and provided technical guidance throughout the course of this study. The study was jointly funded by Supply and Services Canada; the National Museum of Natural Sciences, National Museums of Canada; and Fisheries and Oceans of Canada through Supply and Services contract serial number ISZ79-00146. G. Robins provided administrative and technical support and R. R. Campbell provided financial support and manuscript criticism.

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The information in this report is based on a study by Bradley J. Parker and Paul M. McKee (1980) published in part by McKee and Parker (1982), plus some data collected by Thomas A. Edge in the summer of 1982.

Literature Cited

- Berra, T. M., and R. J. Au. 1978. Incidence of black spot disease in fishes in Cedar Fork Creek, Ohio. *Ohio Journal of Science* 78(6): 318-322.
- Bowman, M. L. 1959. The life history of the black redbhorse, *Moxostoma duquesnei* (Le Sueur) in Missouri. Ph.D. thesis, University of Missouri.
- Burr, B. M. 1980. Common stoneroller, *Camptostoma anomalum*. Pages 143-144 in *Atlas of North American freshwater fishes*. Edited by D. S. Lee, C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and R. J. Stouffer, Jr. State Museum of Natural History, Raleigh, North Carolina. Biology Survey Publication 1980-12.
- Carlander, K. D. 1969. *Handbook of freshwater fishery biology*. Volume 1. Life history data on freshwater fishes

- of the United States and Canada, exclusive of the Perciformes. Iowa State University Press, Ames, Iowa.
- Cross, F. B.** 1967. Handbook of fishes of Kansas. University of Kansas. Museum of Natural History Publication 45: 1-357.
- DeLury, D. B.** 1947. On the estimation of biological populations. *Biometrics* 3(4): 145-167.
- Gruchy, C. G., R. H. Bowen, and I. M. Gruchy.** 1973. First records of the stoneroller (*Campostoma anomalum*) and the blackstripe topminnow (*Fundulus notatus*) from Canada. *Journal of the Fisheries Research Board of Canada* 30: 683-684.
- Gunning, G. E., and W. M. Lewis.** 1956. Age and growth of two important bait species in a cold-water stream in southern Illinois. *American Midland Naturalist* 55: 118-120.
- Hoffman, G. L.** 1967. Parasites of North American freshwater fishes. University of California Press, Los Angeles.
- Hubbs, C. L., and G. P. Cooper.** 1936. Minnows of Michigan. *Cranbrook Institute of Science Bulletin* (8): 1-84.
- Hubbs, C. L., and K. F. Lagler.** 1947. Fishes of the Great Lakes region. *Cranbrook Institute of Science Bulletin* 26: 1-186.
- Langlois, T. H.** 1937. Bait culturists guide. Ohio Department of Agriculture, Division of Conservation, Bulletin (137): 1-23.
- Lennon, R. E., and P. S. Parker.** 1960. The stoneroller, *Campostoma anomalum* (Rafinesque), in Great Smoky Mountain National Park. *Transactions of the American Fisheries Society* 89: 263-270.
- Lewis, W. M., and D. Elder.** 1953. The fish population of the headwaters of a spotted bass stream in southern Illinois. *Transactions of the American Fisheries Society* 82: 193-202.
- McAllister, D. E., and C. G. Gruchy.** 1977. Status and habitat of Canadian fishes in 1976. Pages 151-157 in Canada's threatened species and habitats. *Edited by* T. Mosquin and C. Suchal. Canadian Nature Federation Special Publication 6.
- Menzel, B. W.** 1978. The hybrid combinations of minnows (Cyprinidae) involving members of the common shiner species complex (genus *Notropis*, subgenus *Luxilus*). *American Midland Naturalist* 99(1): 249-253.
- Miller, R. J.** 1962. Reproductive behavior of the stone-roller minnow, *Campostoma anomalum pullum*. *Copeia* 1962(2): 407-417.
- Miller, R. J.** 1964. Behavior and ecology of some North American cyprinid fishes. *American Midland Naturalist* 72(2): 313-357.
- McKee, P. M., and B. J. Parker.** 1982. The distribution, biology, and status of the fishes *Campostoma anomalum*, *Clinostomus elongatus*, *Notropis photogenis* (Cyprinidae), and *Fundulus notatus* (Cyprinodontidae) in Canada. *Canadian Journal of Zoology* 60: 1347-1358.
- Parker, B. J., and P. M. McKee.** 1980. Rare, threatened and endangered fish species of Ontario: status reports. A report submitted to the Department of Supply and Services, Department of Fisheries and Oceans, and National Museum of Natural Sciences. Beak Consultants Limited, Mississauga, Ontario.
- Pfeiffer, R. A.** 1955. Studies on the life history of the rosyface shiner, *Notropis rubellus*. *Copeia* 1955(2): 95-104.
- Pflieger, W. L.** 1975. The fishes of Missouri. Missouri Department of Conservation. Jefferson City, Missouri.
- Reed, R. J.** 1958. The early life history of two cyprinids, *Notropis rubellus* and *Campostoma anomalum pullum*. *Copeia* 1958(4): 325-327.
- Smith, O. R.** 1935. The breeding habits of the stoneroller minnow (*Campostoma anomalum* Rafinesque). *Transactions of the American Fisheries Society* 56: 148-151.
- Trautman, M. B.** 1957. The fishes of Ohio with illustrated keys. State University Press, Columbus, Ohio. [Second edition, 1981].
- Wong, S. L., and B. Clark.** 1976. Field determination of critical concentration for Cladophora in streams. *Journal of the Fisheries Research Board of Canada* 33: 85-92.

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Status of the Blackstripe Topminnow, *Fundulus notatus*, in Canada*

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The Blackstripe Topminnow, *Fundulus notatus*, is restricted in Canada to two southern Ontario counties, Lambton and Kent, in the Sydenham River watershed, where its range occupies a rectangle of less than 10 by 30 kilometres. The species is absent from a considerable proportion of stations within this range. It is rarely common at stations where it is known, and it averages only about 2.6% of the specimens of all species present. Canadian and American populations are separated by considerable expanses of unfavorable lentic habitat. Livestock destruction of stream edge-cover has reduced or extirpated some populations. Seepage from oil wells into one creek is probably inimical to one population of this surface-feeding species. Damage to streamside vegetation, which provides insect food, and to within-stream vegetation, which provides cover, is probably harmful to this species. Because of the highly restricted distribution of this species, its occurrence in only a portion of one watershed, its specialized surface-insect feeding habit, its need for in-stream and stream-side vegetation, and the occurrence of some habitat threats in its Ontario range, this species is judged to be rare in Canada.

Au Canada, on ne trouve le fondule rayé, *Fundulus notatus*, que dans deux comtés du sud de l'Ontario (Lambton et Kent), plus précisément dans le bassin de la rivière Sydenham, à l'intérieur d'un rectangle de moins de 10 km sur 30 km. L'espèce est absente d'un nombre considérable mais encore inconnue de sites d'observation dans les limites de cette aire. On la trouve rarement en grand nombre aux sites qu'elle fréquente habituellement, où elle représente en moyenne quelque 2,6% des spécimens présente de toutes les espèces observées. Les populations du Canada et des États-Unis sont séparées par d'importantes étendues d'habitat lentique non favorable à l'espèce. La destruction, par le bétail, de la végétation en bordure des cours d'eau a réduit ou même déraciné certaines populations. L'écoulement de pétrole dans un des ruisseaux nuit probablement à l'une des populations de cette espèce qui se nourrit en surface. L'altération de la végétation du bord de l'eau, où se trouvent les insectes dont il se nourrit, et celle des plantes aquatiques, qui lui servent d'abri, est vraisemblablement néfaste au fondule rayé. Étant donné sa répartition très restreinte, sa présence dans un seul secteur du bassin étudié, son régime axé sur les insectes de surface, son besoin de végétation aquatique et certaines menaces qui pèsent sur son habitat de l'Ontario, l'espèce est considérée comme étant rare au Canada.

Key Words: Blackstripe Topminnow, *Fundulus notatus*, Ontario, rare fish, killifish, Cyprinodontidae.

The Blackstripe Topminnow, *Fundulus notatus*, can be recognized by the prominent black horizontal band along the side of both body and head, the rounded tail fin, the flattened top of the head, and the large round scales on top of the head, cheek and gill covers (Figure 1). An opal-coloured spot on the top of the head makes this species easy to recognize in life, but the spot disappears after death. The related Banded Killifish, *Fundulus diaphanus*, which also occurs in Ontario, has 40 to 55 scales along the side instead of 32 to 35, and has vertical bars instead of a black horizontal band.

Distribution

The following account of the distribution of the Blackstripe Topminnow is based on Shute (1980), on results of recent studies (Parker and McKee 1982) and on a survey by Thomas A. Edge in 1982.

In the United States the Blackstripe Topminnow is widespread throughout the central eastern United States (Figure 2). It ranges in the Gulf states from the San Antonio River drainage in Texas to Mobile Bay tributaries in western Alabama. In the Mississippi River basin the species is found in many lowland areas from southern Mississippi to Illinois, Ohio, Michigan, Iowa, and Wisconsin. In the Great Lakes basin it has been collected from tributary streams of southern Lake Michigan, Lake St. Clair, and Lake Erie.

In Canada the Blackstripe Topminnow is limited to the Sydenham River watershed in southwestern Ontario (Figure 3). It has been captured in the North Sydenham River from Wallaceburg, Lambton County (42°38'20"N, 82°22'32"W), to Bear Creek at Petrolia, Lambton County (42°17'12"N, 82°08'55"W). This species also occurs in Fox Creek (42°48'N, 82°09'W) and Crooked Creek (42°46'N, 82°16'W), both tributaries of Black Creek in Lambton County. A single collection of the Blackstripe Topminnow was made in Otter Creek, Kent County (42°36'58"N, 82°18'05"W), which enters the North Sydenham River at Wallaceburg. A single specimen in the

*Rare status approved and assigned by COSEWIC April 1985.

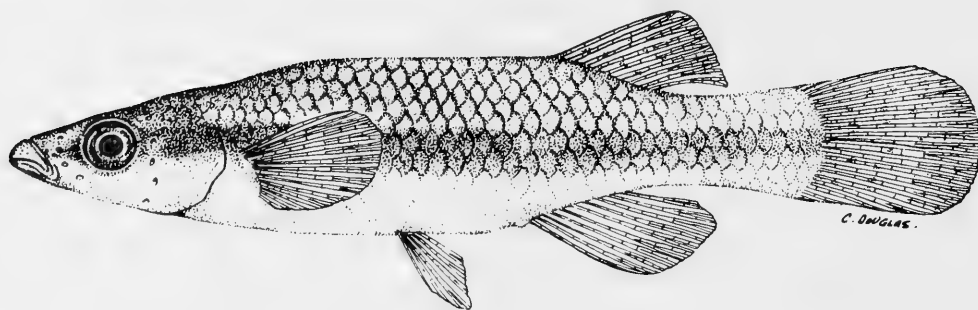


FIGURE 1. Blackstripe Topminnow, *Fundulus notatus* (drawing by C. H. Douglas, National Museum of Natural Sciences).

National Museum of Natural Sciences labeled Mollys Creek, Kent County (42° 36'N, 82° 10'W), which flows into the Sydenham River near Dresden, is open to some doubt as to its provenance (C. G. Gruchy, personal communication). The most recent collections of the Blackstripe Topminnow were made by Thomas A. Edge in June and July 1982. These were from the North Sydenham River 1 km east of Wilkesport (school of about 30 seen); Bear Creek, 17 km east of Bickford (about 10 seen); Black Creek about 12 km east of Brigden (about 50 observed at the surface). All of Edge's observations were in Lambton County, Ontario. Voucher specimens and records are deposited in the National Museum of Natural Sciences, Ottawa.

The known range of the Blackstripe Topminnow in Canada occupies an area of about 10 by 30 km and is located about 200 km north of the nearest population in the United States. Canadian and American populations are separated by considerable expanses of unfavorable lentic habitat.

Protection

No legal or other protection has been accorded the Blackstripe Topminnow in Canada other than the general protection of the habitat section of the Fisheries Act.

Population Size and Trend in Canada

No population estimates have been made of the Blackstripe Topminnow in Canada, and there is no direct evidence on population trends. The species was first discovered in Canada in 1972 (Gruchy et al. 1973).

Within its small known Canadian range Blackstripe Topminnow adults and young appear in moderate abundance. Individuals and groups of three to five were observed near the upstream and downstream limits of the species in Ontario. Pools in intermittent streams in the headwaters of Black Creek seemed to

provide optimal habitat: 20 to 30 Topminnows were observed in a long, narrow pool of about 200 square metres. Destruction of aquatic vegetation and bank cover by livestock limits available habitat area in the headwaters of Black Creek. Few specimens were collected in these altered habitats.

Intrusion of less turbid water from the St. Clair River into the North Sydenham River at Wallaceburg appears to limit the downstream movement of this species and may limit its further dispersal in the Lake St. Clair drainage. Riffles and increased gradient above Petrolia curtail its upstream dispersal in Bear Creek. Tolerance to turbid water might suggest that this species will expand its range elsewhere into existing turbid waters or into waters that become turbid. However, this assumes that other habitat requirements will be met. Loss of stream bank cover may increase turbidity but decrease the supply of terrestrial insects which constitute > 50% of foregut volumes in 13 Ontario specimens examined in 1979. Thus, although Trautman (1957) noted that this species is more tolerant of turbidity than the Banded Killifish and tended to replace it when turbidity increases, he reported marked decreases in the abundance of Blackstripe Topminnows in sections of Ohio which showed the greatest increases in turbidity from 1925 to 1950. Trautman further stated that the largest populations were found in relatively clear water.

Habitat

In Ontario the Blackstripe Topminnow occurs in permanent and intermittent sluggish creeks and rivers. Stream gradients in the North Sydenham River watershed range from 0.02 m/km to over 6 m/km. This species was found in permanent flowing waters with gradients less than 0.7 m/km and in intermittent streams with higher gradients. Specimens were collected from Crooked Creek with a gradient of about 5.6 m/km, and in the headwaters of Black

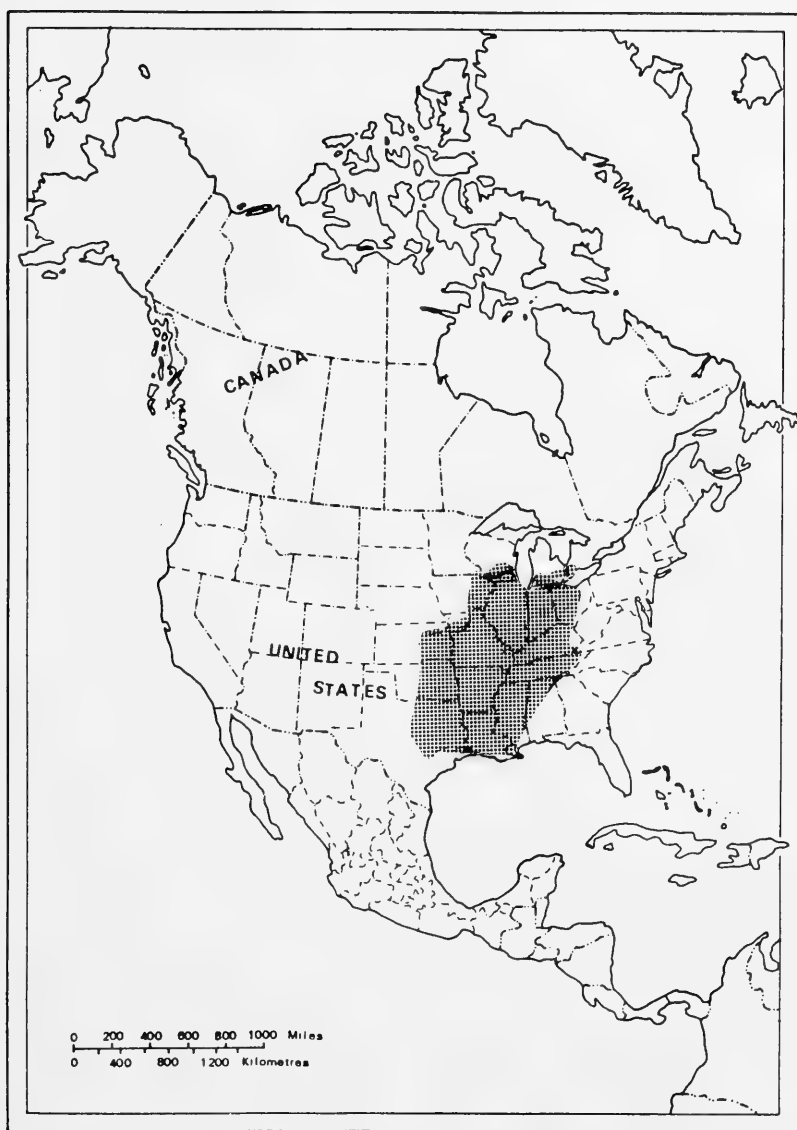


FIGURE 2. North American distribution of *Fundulus notatus* (adapted from Shute 1980).

Creek where the gradient averages 1.4 m/km. Isolated pools of water, 1 to 2 metres deep and separated by dry stream bed, characterize the upper reaches of Black Creek during the late summer. Water flow is virtually absent between these pools.

Trautman (1957) and Shute (1980) also reported that the Blackstripe Topminnow prefers small to large low-gradient streams, and Atmar and Stewart (1972) mentioned that this species was found in pools in intermittent streams, as in Black Creek.

Emergent and floating aquatic macrophytes and low overhanging terrestrial plants are extensively used as cover by the Blackstripe Topminnow. In the North Sydenham River, cover is available only near the river edges. This species was rarely observed beyond this edge cover in open waters. Blackstripe Topminnows were observed in midstream in smaller tributaries, but protective cover was always nearby. In areas where edge-cover had been destroyed by livestock, the Blackstripe Topminnow was less numerous or absent.



FIGURE 3. Collection records of the Blackstripe Topminnow in Ontario (adapted from Parker and McKee 1980).

On several occasions during this study this species was observed seeking and utilizing in-stream cover. When approached, these fish would dart into dense growth of cattails, *Typha*; Arrowhead, *Sagittaria latifolia*; spatterdock, *Nuphar*; or lily pads, *Nymphaea*.

Erosion of fine clay soils from the surrounding countryside results in high turbidity in the North Sydenham River watershed. The Blackstripe Topminnow appears to be quite tolerant of waters with high turbidity, and may prefer, or preferentially survive, in such habitats. It becomes more numerous in the North Sydenham River as turbidity increases. Inflow of clear St. Clair River water into the North Sydenham River increased water transparency from approximately 10 cm 4.5 km upstream, to approximately 35 cm near Wallaceburg. It is over this 4.5 km stretch of river that the downstream distribution of Blackstripe Topminnows ends. Shute (1980) also reported that this species occurs in streams of moderate to high turbidity. Trautman (1957) observed that this species is more tolerant of turbidity than is the Banded Killifish and tends to replace the

Banded Killifish when turbidity increases. Paradoxically, Trautman also reported marked decreases in the abundance of Blackstripe Topminnows in sections of Ohio which showed the greatest increases in turbidity from 1925 to 1950 and stated that the largest populations are found in relatively clear water.

The Blackstripe Topminnow is apparently tolerant of a wide range in water quality. Although water temperatures at capture sites ranged only from 20 to 25°C, temperatures in some of the isolated pools in the headwaters of Black Creek were warmer as a result of decreased waterflow during hot weather. Oxygen levels of 7 and 8.5 mg/L were measured in two pools in Black Creek, but oxygen levels in the shallow isolated pools likely decrease at night since aeration is minimal.

In winter the Blackstripe Topminnow abandons its surface swimming habitat and moves to deeper waters among vegetation and plant debris.

The trends in quality and quantity of critical habitat are unknown. These will depend to a large degree on changes in agricultural practices which may be relatively stable. On the other hand, the changing

economy, development of new agricultural products, or consumer preferences may dictate changes in crops. If permanent stream-side vegetation is encouraged, this might decrease turbidity but in turn increase the availability of terrestrial insects. It might be worthwhile to conduct experiments on different farming management practices on sections of streams where the Blackstripe Topminnow occurs. Populations of this species, which unlike many other fish species can be surveyed by terrestrial observation, could be determined before and after changes (even the uninitiated may identify this surface species by the iridescent spot on top of the head).

General Biology

Reproductive Capability

Spawning has not been observed in Ontario, but Carranza and Winn (1954) have observed reproductive activity of this species in Michigan from early May to the third week in August. A similar spawning period is likely in Ontario waters.

Spawning takes place amongst aquatic vegetation. Carranza and Winn (1954) stated that during the breeding season females are often observed in thick vegetation along the shoreline, while males congregate further from shore. As spawning activity increases, territories are established parallel to the shore by mating pairs. Twenty to thirty adhesive eggs are extruded and fertilized one at a time. Each egg is propelled into the submerged vegetation by the male. Spawning may continue over an extended period as more eggs ripen.

Spawning behavior, spawning substrate, and egg and larval stages of the Blackstripe Topminnow were described by Foster (1967).

Sexual dimorphism is quite apparent in the Blackstripe Topminnow. Differences exist in fin shape, fin marking, and body coloration. The male exhibits dark vertical bars extending above and below the mid-lateral stripe, but these bars are absent in the female. The male has yellowish fins while the female has white fins. The posterior portions of the dorsal and anal fins are elongated in the male and rounded in the female. Coloration and fin shape are related to sex recognition, display, and the reproductive set. A full description of reproductive behaviour is provided by Carranza and Winn (1954).

Feeding Behaviour

Blackstripe Topminnows were often observed feeding alone or in small groups just under the water surface. The upturned mouth of this species also suggests a surface feeding habit. The foregut contents of 13 specimens collected during 1979 were composed primarily of adult terrestrial insects (> 50% by volume, 100% frequency of occurrence), indicating

that surface feeding is important to this species. The presence of larval insects, crustaceans, molluscs, and filamentous algae indicates that midwater and bottom foraging is also important. Considerable variation was found among the diets of fishes examined.

Atmar and Stewart (1972) studied the feeding habits of the Blackstripe Topminnow and also found that terrestrial insects comprised much of the diet, while snails, aquatic insects, and microcrustaceans accounted for less. These authors also found that algae are apparently ingested incidentally during the consumption of prey, but are not digested. Variation in prey selected by this species was attributed to an opportunistic feeding habit.

Growth

Blackstripe Topminnows collected in Ontario were aged using scales as described by Nieman and Wallace (1974). Scales from 15 specimens captured during August 1979 and from 8 specimens captured between June and August 1972 were aged. Standard lengths of young-of-the-year of this species ranged from 15 to 32 mm, while fish aged 1+ years ranged from 38 to 50 mm, and 2+ fish ranged from 41 to 51 mm in length. The largest fish captured in 1979 was 51 mm in standard length and weighed 2.3 grams (preserved weight). Total lengths given by Trautman (1957), Carlander (1969), and Nieman and Wallace (1974) range from 50 to 70 mm in total length, with a maximum total length of 74 mm.

The maximum age of Ontario specimens was two years. Nieman and Wallace (1974) reported 3+ specimens; however, Carranza and Winn (1954), Trautman (1957), Thomerson (1966), and Atmar and Stewart (1972) reported 2+ as the maximum age of the Blackstripe Topminnow.

Sex-related differences in size in this species are not apparent except when females are distended with eggs (Carranza and Winn 1954; Nieman and Wallace 1974).

Predation

Information on predation of Blackstripe Topminnows is scant. Piscivorous fish were apparently absent in many of the isolated pools of Black Creek during the 1979 survey. Piscivorous species captured in Bear Creek and the North Sydenham River with the Blackstripe Topminnow were Longnose Gar, *Lepisosteus osseus*, Northern Pike, *Esox lucius*, Rock Bass, *Ambloplites rupestris*, White Crappie, *Pomoxis annularis*, and Largemouth Bass, *Micropterus salmoides*. Predation by some of these fish on the Blackstripe Topminnow is very likely. Atmar and Stewart (1972) suggested that low numbers of larger Blackstripe Topminnows in Texas may be due to selective predation by the Belted Kingfisher, *Megasceryle alcyon*.

Parasites

Parasite copepods of the genus *Lernaea* infested 2 of 16 Blackstripe Topminnows examined from the 1979 survey. Hoffman (1967) listed cestodes, nematodes and Acanthocephala as parasites of this species, and Shira (1913), as cited by Hart and Fuller (1974), found this species was parasitized by unionid glochidia.

Species Movement

There is little information on seasonal movement in Ontario. Individuals may become concentrated in pools by partial drying of the stream bed in summer, and may move into deeper water of pools. The concentration into pools of drying stream beds in summer does increase the risks of exposure to agricultural chemicals or other pesticides, as well as to avian predation.

Behaviour/Adaptability

The Blackstripe Topminnow has survived despite current farming practices in southern Ontario. However, livestock destruction of edge-cover has reduced or extirpated some populations. Human disturbance reducing the emergent and floating aquatic macrophytes or overhanging terrestrial plants that serve as cover, as a source of terrestrial insect food, or as substrate for egg deposition or nursery areas may be detrimental to the success or survival of the species. The species does appear fairly euryphagous, but terrestrial insects taken from the surface of the water supply a very significant portion of the food intake. Measures such as spraying of insecticides and reduction in stream bank vegetation, which reduce this food supply may be expected to have detrimental effects.

The species is able to survive for periods in pools when other portions of the stream bed dry up. Land use practices which result in completely dry stream beds would obviously extirpate populations. Channelization, which results in more rapid flow to which this species is ill-adapted, may be expected to be inimical.

Limiting Factors

It has not been established whether or not populations are declining in southern Ontario. However, population size is probably limited by the amount of stream-side vegetation, aquatic vegetation, and stream-side terrestrial insect fauna may limit population size. Channelization and drainage of wetlands may produce inimical changes in stream flow patterns. Blackstripe Topminnows extend only part way up the lower Michigan Peninsula, just as they are found only in southernmost Ontario. Given time, one might have expected them to have dispersed further north had ecological conditions been suitable.

It is deduced that some climatic factor, such as severity of winter conditions, limits northward range extension.

The seepage of oil wells into Black Creek in the vicinity of Oil Springs is expected to have especially damaging potential for a species which feeds to such a high degree on surface food in summer.

Special Significance of the Species

The Blackstripe Topminnow is one of three species of the genus *Fundulus* found in Canadian waters. Along with populations in northern Michigan, the southern Ontario populations comprise the northernmost range of the species and may have special genetic characteristics. Ecologically the topminnows play an important role in the exclusivity with which they feed on surface insects in summer. Other fishes do feed on surface insects but do not rely on them to the same extent.

Evaluation

The Canadian population probably occupies a small area because the species is at the northern end of its range. Riparian plant cover, aquatic macrophytes, and stream-side terrestrial insect food may be limiting population size. Destruction of stream bank cover and oil well seepage may be reducing or extirpating some populations. The species should be considered rare in Canada.

Acknowledgments

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Some of the original recommendations by Parker and McKee (1980) have been modified in this report.

Literature Cited

- Atmar, G. and K. M. Stewart. 1972. Food, feeding and ecological efficiencies of *Fundulus notatus* (Cyprinodontidae). American Midland Naturalist 88: 76-89.
- Carlander, K. D. 1969. Handbook of freshwater fishery biology. Volume 1. Life history data on freshwater fishes of the United States and Canada, exclusive of the Perciformes. Iowa State University Press, Ames, Iowa.
- Carranza, J., and H. E. Winn. 1954. Reproductive behavior of the blackstripe topminnow, *Fundulus notatus*. Copeia 1954 (2): 273-278.

- Foster, N. R.** 1967. Comparative studies on the biology of killifishes (Pisces, Cyprinodontidae). Ph.D. thesis, Cornell University, Ithaca, New York.
- Gruchy, C. G., R. H. Bowen, and I. M. Gruchy.** 1973. First records of the stoneroller (*Campostoma anomalum*) and the blackstripe topminnow (*Fundulus notatus*) from Canada. *Journal of the Fisheries Research Board of Canada* 30: 683-684.
- Hart, C. W. Jr., and S. L. H. Fuller. Editors.** 1974. *Pollution ecology of freshwater invertebrates*. Academic Press, New York.
- Hoffman, G. L.** 1967. *Parasites of North American freshwater fishes*. University of California Press, Los Angeles.
- McAllister, D. E., and C. G. Gruchy.** 1977. Status and habitat of Canadian fishes in 1976. Pages 151-157 in *Canada's threatened species and habitat. Edited by T. Mosquin and C. Suchal*. Canadian Nature Federation Special Publication Number 6.
- McKee, P. H., and B. J. Parker.** 1982. The distribution, biology, and status of the fishes *Campostoma anomalum*, *Clinostomus elongatus*, *Notropis photogenis* (Cyprinidae), and *Fundulus notatus* (Cyprinodontidae) in Canada. *Canadian Journal of Zoology* 60: 1347-1358.
- Nieman, R. L., and D. C. Wallace.** 1974. The age and growth of the blackstripe topminnow, *Fundulus notatus* Rafinesque. *American Midland Naturalist* 92: 203-205.
- Parker, B. J., and P. M. McKee.** 1980. Rare, threatened and endangered fish species of Ontario: status reports. A report submitted to Department of Supply and Services, Department of Fisheries and Oceans, and National Museum of Natural Sciences. Beak Consultants Limited, Mississauga, Ontario.
- Shira, A. F.** 1913. The mussel fisheries of Caddo Lake and the Cypress and Sulphur rivers of Texas and Louisiana. United States Bureau of Fisheries Economic Circular Number 6: 1-20.
- Shute, J. R.** 1980. Blackstripe topminnow, *Fundulus notatus*. Page 521 in *Atlas of North American freshwater fishes. Edited by D. S. Lee, C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and R. J. Stouffer, Jr.* North Carolina State Museum of Natural History, Raleigh, North Carolina. Biological Survey Publication Number 1980-12.
- Trautman, M. B.** 1957. *The fishes of Ohio with illustrated keys*. Ohio State University Press, Columbus, Ohio [Second edition, 1981.]

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Status of the Brindled Madtom, *Noturus miurus*, in Canada*

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Parker, B., and P. McKee. 1987. Status of the Brindled Madtom, *Noturus miurus*, in Canada. *Canadian Field-Naturalist* 101(2): 226-230.

The Brindled Madtom, *Noturus miurus*, is rare in Canada and has been reported only from certain tributaries of Lake Erie and Lake St. Clair in Ontario. Despite repeated efforts to capture this species during 1979 using a variety of methods, including day and night sampling, none were captured. Population levels may be extremely low but the species is secretive and not often seen. The Brindled Madtom is not specifically protected in Canada, although general protection is afforded through the fish habitat sections of the Fisheries Act.

Le chat-fou tacheté, *Noturus miurus*, est rare au Canada, où il n'a été signalé que dans certains tributaires des lacs Érié et Sainte-Claire, en Ontario. Malgré des efforts répétés et l'utilisation de différentes méthodes, on n'a pas réussi à le capturer au cours d'échantillonnages menés de jour et de nuit en 1979. Par conséquent, le poisson doit être rare, mais ils sont réservés et ne sont pas souvent vus. Le chat-fou tacheté ne bénéficie pas d'une protection particulière au Canada, mais il est protégé de façon générale en vertu de l'article sur la protection de l'habitat du poisson de la Loi sur les pêcheries.

Key Words: Brindled Madtom, *Noturus miurus*, catfish, Ontario, rare fishes.

The Brindled Madtom, *Noturus miurus*, is one of the smaller catfishes in Canada with adnate fins (Figure 1). Adults may be 5 to 7 cm in length with the heaviest part of the body anterior (Scott and Crossman 1973). The species occurs in the freshwater basins of east-central North America in clean, fast-flowing streams with gravel bottoms or in pools below riffles.

These fish have peculiar markings which give rise to the common name. The Brindled Madtom is typically yellow, brown, reddish-orange or pink with four dark saddle marks on the back. The sides are mottled, and vertically they are usually white or pale yellow (Scott and Crossman 1973). The species is secretive and seldom seen and is one of three Canadian freshwater fishes with pectoral spines associated with a poison gland which may cause painful wounds (Reed 1907; Scott and Crossman 1973).

Distribution

The Brindled Madtom is found in the lower Great Lakes basin, the Mississippi River system and the Pearl River system. In the Mississippi River system the Brindled Madtom is recorded from the Mississippi River, the Ohio River valley, the Tennessee River valley and the Arkansas River (Rhode 1980). Reports of this species occurring in the Illinois River system and in the states of Wisconsin, Illinois, Minnesota, and Iowa are questionable (Taylor 1969). A collection

from the Kaskaskia River, Illinois, has been verified (Taylor 1969). In the Great Lakes basin the Brindled Madtom has been recorded from tributaries of Lake St. Clair and Lake Erie in Ontario, Michigan, and Ohio. Scott and Crossman (1973) reported this species from the Niagara River. Taylor (1969) reported the Brindled Madtom from the Finger Lakes, New York state, which drain into Lake Ontario. Taylor also states that this species does not occur in Lake Huron or Lake Superior, and that records from Lake Michigan are in doubt. Several populations disappeared or decreased in abundance in Ohio between 1893 and 1950 due to clayey silts covering over the organic debris and the sand and gravel bottom habitat (Trautman 1981).

In Canada the Brindled Madtom has been recorded in Lake Erie and its tributary streams and in tributary streams of Lake St. Clair (Figures 2 and 3). In the Lake Erie basin it has been reported from Long Point Bay, Norfolk County (42°40'N, 80°10'W) [Reid 1978]; Turkey Point, Norfolk County (42°40'N, 80°22'W); Dedrick Creek, Norfolk County (42°37'N, 80°28'W); Catfish Creek, Elgin County (42°39'N, 81°00'W) [Radforth 1944]; and Dodd Creek, Elgin County (42°46'N, 81°12'W). In the Lake St. Clair basin it has been captured in the Sydenham River at Wallaceburg, Kent County (42°35'N, 82°21'W); in an unnamed tributary of the Sydenham River, Middlesex County (42°49'N, 81°52'W); in Bear Creek, Warwick and Enniskillen townships, Lambton County (42°58'N, 81°58'W); and in Fansher Creek, Lambton County (42°39'N, 82°00'W).

*Rare status approved and assigned by COSEWIC April 1985.

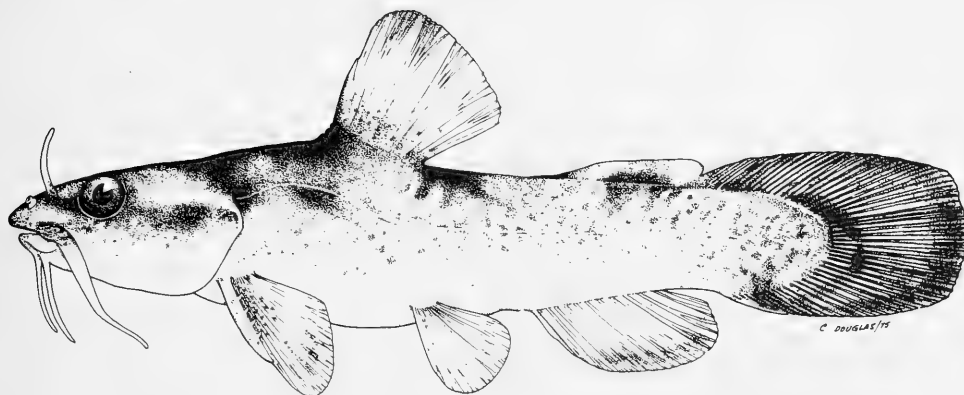


FIGURE 1. Brindled Madtom, *Noturus miurus* (drawing by C.H. Douglas; courtesy D. E. McAllister, National Museum of Natural Sciences).

Protection

International

Reported as rare in Kansas (Platt 1974), but not as threatened or endangered for any state by Miller (1972).

National

Not specifically protected in Canada, although afforded general protection by the fish habitat sections of the Fisheries Act.

Population Size and Trends

The population structure of the Brindled Madtom in Canada is not fully known. Reports of the occurrence of this species in southern Ontario date back to 1929 (Redforth 1944). These early reports are from the Sydenham River, near Alvinston, and in Dedrick Creek which flows into Lake Erie. Capture records from the mid-1970s closely approximate the localities from which this species was collected fifty years ago.

Although collections of the Brindled Madtom are sporadic and temporally dissociated, museum records suggest that small viable populations might still be present in southern Ontario. Records exist from Lake Erie, at Long Point and Turkey Point, and from inflowing tributaries of Lake Erie, Kettle Creek, Catfish Creek, and several early Ontario capture sites. The species is secretive and difficult to collect due to its nocturnal habits (Scott and Crossman 1973).

Scott and Crossman (1973) summarize published information and McAllister and Gruchy (1977) comment on the status of this species in Canada. The species is quite rare (McAllister and Gruchy 1977), being captured sporadically in southwestern Ontario during the past fifty years.

Habitat

The Brindled Madtom was not captured during a recent survey (Parker and McKee 1980); therefore, only a review of Canadian capture localities and a comparison with data from more southerly populations can be provided.

In Canada, the Brindled Madtom has been captured in lake, river and stream environments. Scott and Crossman (1973) reported that specimens taken in Ontario were from clear, fast flowing streams with gravel bottoms. Collections made during the 1970s diversified the habitat preference by including shallow lake environments over detrital and sand bottoms, and moderate to base gradient streams that were sluggish and turbid. Trautman (1957) stated that the largest populations of this species in Ohio were located in base or low gradient streams with substrates composed of sand and organic debris where viscous clayey silts were negligible or absent. Smaller numbers of Brindled Madtoms occurred in riffles of sluggish to moderate flow and occasionally in pools among aquatic vegetation. Trautman (1980) suggested that the Brindled Madtom had been captured under flat rocks in shallow waters around the Bass Islands in Lake Erie. Pflieger (1975) and Taylor (1969) report Brindled Madtoms in low gradient streams over a variety of substrates including sand, debris and soft mud or muck.

Bowen (1980) provides detailed information on habitat preference in an Ohio population. He found that during the summer months overhanging protective bank edges and eddies created by riffles in moderate to low gradient stream sections were preferred. Pools may serve as overwintering habitat. The stream which he studied was about 0.3 m deep in

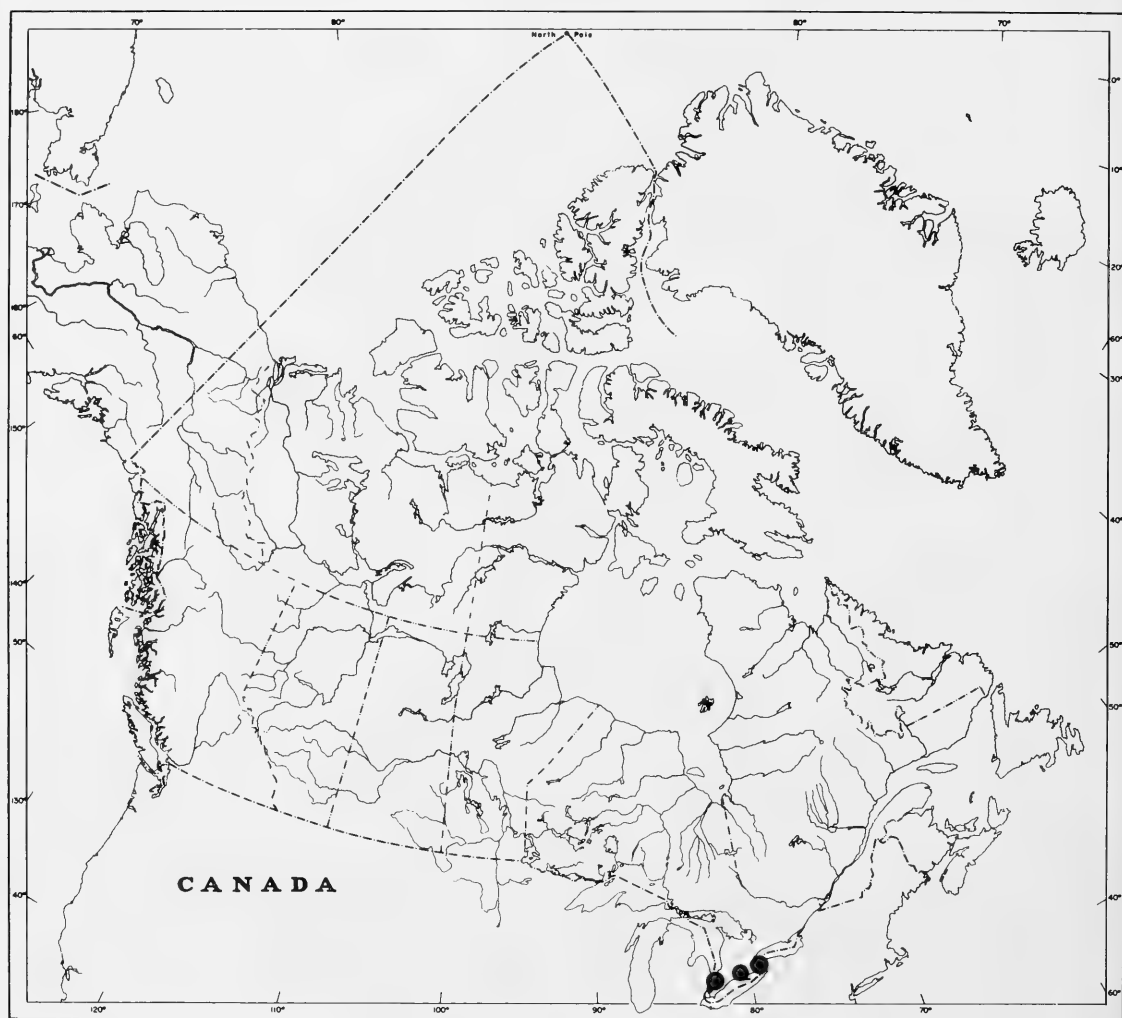


FIGURE 2. Canadian distribution of *Noturus miurus*.

capture areas. Bottoms composed of detritus or large flat rocks and sand were preferred.

Based on the description of preferred habitat, it is suggested that the majority of prior capture sites in southwestern Ontario provide only a marginally suitable habitat. Water quality in the lower Sydenham River may no longer be suitable for the Brindled Madtom as a result of the deposition of clay silts.

General Biology

Bowen (1980) believes that individuals mature during their third summer; however, specimens under 50 mm were sexually mature. Bowen (1980) found that the the Brindled Madtom spawned at tempera-

tures ranging from 25 to 27°C in Ohio, usually during the last two weeks in July and the first two weeks in August. Brooding pairs constructed nests under flat rocks up to 1 m in diameter in areas with slight currents. Scott and Crossman (1973) noted that in Michigan spawning took place in mid to late summer at temperatures of 25.6°C over a bottom of silt and mud in the vicinity of emergent vegetation. Taylor (1969) and Bowen (1980) suggest that brooding pairs may utilize open-ended tin cans for brooding areas when other suitable natural habitat is at a premium. Bowen (1980) observed spawning activity and nest building in aquaria. He noted that both parents are involved in nest building and in nest guarding after



FIGURE 3. Collection records of the Brindled Madtom in Ontario.

spawning. Several days after spawning occurred, he observed that the female left the nest and the male continued to guard the eggs until hatching occurred (in about two weeks). Average number of young in six broods ranged from 34 to 46. Eggs are large, amber and adhesive (Scott and Crossman 1973).

Hybrids occur between the Brindled Madtom and the Tadpole Madtom, *Noturus gyrinus*, and Slender Madtom, *Noturus exilis* (Trautman 1957; Taylor 1969).

Bowen (1980) has conducted food habit studies over a 12-month period and suggests that the Brindled Madtom feeds heavily on drift invertebrates. From stomach analysis of 276 individuals, he found that chironomid larvae predominated, followed by copepods and trichopterans. Scott and Crossman (1973) suggest they are nocturnal in habit; Bowen (1980) reported that the majority of Brindled Madtoms captured during his study were captured at night, suggesting nocturnal feeding habits.

Little information has been published on the age and growth of the Brindled Madtom in Canada. Bowen (1980) describes a new method of age

determination using otoliths. Maximum age was identified by retaining live specimens in an aquarium system until death. Bowen found that the maximum age was approximately 25 months. He also recorded a maximum length of 126 mm. The largest Canadian specimen is 87 mm total length (NMC 72-0131). Trautman (1957) reported a maximum size of 132 mm. Trautman also provided lengths at various ages: young-of-the-year in Ohio ranged from 25-56 mm in length by October, 36-64 mm in length after one year, and 56-97 mm in length for adults. Differences in growth rate between male and female have not been noted.

Predators of the Brindled Madtom are believed few as a result of its secretive and nocturnal habits. Gar, *Lepisosteus* sp., are the only documented predators of this species (Scott and Crossman 1973).

Hoffman (1967) lists only four trematodes and concludes that the Brindled Madtom is relatively parasite-free. The dominant parasites which infested this species in an Ohio population were members of the Proteocephalidae [Cestoda] (Bangham and Hunter 1939; Bowen 1980).

Limiting Factors

Given the tolerance of the species to a wide variety of habitats, habitat destruction does not seem likely to be a major influence on population levels. Some toxic pollutants may be limiting to the population but documentation does not exist. Trautman (1981) does note negative effects of siltation on habitat and population numbers in Ohio.

Special Significance of the Species

As representative of the northernmost population of this species, Ontario populations are of special ecological interest. It is one of three freshwater fishes in Canada with pectoral spines associated with a poison gland. A wound from the spine is painful but not dangerous (Scott and Crossman 1973).

Evaluation

The status of the Brindled Madtom in the Long Point area of Lake Erie and in the Sydenham River watershed is uncertain, but the available information shows that population levels are extremely low. The Canadian population of the Brindled Madtom is at the northeastern extremity of its North American range, and the species is secretive and nocturnal in its habits and therefore difficult to collect. However, fairly accurate estimates of abundance could be ascertained under favourable conditions (see Trautman 1981).

The Brindled Madtom should be classed as a rare species in Canada with the knowledge that all the present range is within an area where aquatic habitats are subject to severe stress and require protection.

Acknowledgments

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Literature Cited

- Bangham, R. V., and G. W. Hunter III. 1939. Studies on fish parasites of Lake Erie. Distribution studies. *Zoologica* 24(4): part 27: 385-448.
- Bowen, C. A. 1980. Life history of the brindled madtom, *Noturus miurus* (Jordan) in Salt Creek, Ohio. M.Sc. thesis, Ohio State University, Columbus, Ohio.

- Hoffman, G. L. 1967. Parasites of North America freshwater fishes. University of California Press, Los Angeles, California.
- McAllister, D. E., and C. G. Gruchy. 1977. Status and habitat of Canadian fishes in 1976. Pages 151-157 in Canada's threatened species and habitats. Edited by T. Mosquin and C. Suchal. Canadian Nature Federation Special Publication 6.
- Miller, R. R. 1972. Threatened freshwater fishes of the United States. Transactions of the American Fisheries Society 101(2): 239-252.
- Parker, B., and P. McKee. 1980. Rare, threatened and endangered fishes in southern Ontario: Status reports. A report for the Department of Supply and Services, Department of Fisheries and Oceans, and National Museum of Natural Sciences. Beak Consultants Limited, Mississauga, Ontario.
- Pflieger, W. L. 1975. The fishes of Missouri. Missouri Department of Conservation, Columbia, Missouri.
- Platt, D. R. 1974. Rare, endangered and extirpated species in Kansas. Transactions of the Kansas Academy of Science 76: 97-106.
- Radforth, I. 1944. Some considerations on the distribution of fishes in Ontario. Contributions of the Royal Ontario Museum, Zoology 25: 1-116.
- Reed, H. D. 1907. The poison glands of *Noturus* and *Schilbeodes*. American Naturalist 41(489): 553-566.
- Reid, O. J. 1978. The fish community within a cattail marsh bordering inner Long Point Bay, Lake Erie. Ontario Ministry of Natural Resources, Southwestern Region, London, Ontario.
- Rhode, F. C. 1980. The brindled madtom, *Noturus miurus*. Page 464 in Atlas of North American freshwater fishes. Edited by D. S. Lee, C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and R. J. Stouffer, Jr. North Carolina State Museum of Natural History, Raleigh, North Carolina. Biological Survey Publication Number 1980-12.
- Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
- Taylor, W. R. 1969. A revision of the catfish genus *Noturus* Rafinesque, with an analysis of higher groups in the Ictaluridae. U.S. National Museum Bulletin 232: 1-315.
- Trautman, M. B. 1957. The fishes of Ohio with illustrated keys. Ohio State University Press, Columbus, Ohio.
- Trautman, M. B. 1981. The fishes of Ohio with illustrated keys. Second edition. Ohio State University Press, Columbus, Ohio.
- Van Meter, A. D., and M. B. Trautman. 1970. An annotated list of the fishes of Lake Erie and its tributary waters exclusive of the Detroit River. Ohio Journal of Science 70(2): 65-78.

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Status of the Salish Sucker, *Catostomus* sp., in Canada*

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McPhail, J.D. 1987. Status of the Salish Sucker, *Catostomus* sp., in Canada. *Canadian Field-Naturalist* 101(2): 231–236.

The Salish Sucker, *Catostomus* sp., is an undescribed fish closely related to the Longnose Sucker, *Catostomus catostomus*. The species is part of the Chehalis fauna, and in Canada its distribution is restricted to the headwaters of the Campbell and Salmon rivers and Bertrand, Pepin and Salwein creeks in the lower Fraser River valley. Numbers have declined in all populations over the last decade and it may already be extirpated in the Campbell River. The main cause of the decline appears to be habitat change associated with urbanization. In British Columbia, this sucker is clearly endangered.

Le meunier de Salish, *Catostomus* sp. est une espèce non décrite apparentée au meunier rouge, *Catostomus catostomus*. L'espèce fait partie de la faune de la Chehalis; au Canada, sa répartition est restreinte aux eaux d'amont des rivières Campbell et Salmon et aux ruisseaux Bertrand, Pepin et Salwein situés dans la vallée inférieure de la rivière Fraser. Au cours de la dernière décennie, toutes les populations ont subi un déclin; l'espèce est peut-être déjà déracinée dans la rivière Campbell. La modification de l'habitat associée au développement urbain semble être la cause principale de ce déclin. En Colombie-Britannique ce meunier est assurément menacé de disparition.

Key Words: Salish Sucker, Catostomidae, British Columbia, endangered species, Chehalis fauna.

In 1947, L. P. Schultz drew attention to an unusual sucker found in Lake Cushman on the Olympic Peninsula. He suggested that this sucker, along with the Olympic Mudminnow, *Novumbra hubbsi*, and Whitefish, *Prosopium snyderi*, indicated the existence of a unique freshwater fish fauna in the Olympic area of western Washington. Schultz suggested that this sucker was related to the Longnose Sucker, *Catostomus catostomus*, but he never gave it a name (Schultz 1947). Since 1947, the existence of this sucker and its zoogeographic implications have been ignored (Lee et al. 1980).

McPhail (1967) reviewed the distribution of fishes in western Washington and discussed their zoogeography. He pointed out that the area south of Puget Sound was ice-free during the entire Pleistocene, and thus the major river of the area (the Chehalis River) acted as a glacial refuge for a number of species. Comparison of the lower Columbia and Chehalis fish faunas revealed a number of important differences. There is a genus, *Novumbra*, in the Chehalis system and in a few formerly glaciated rivers to the north of the Chehalis that is absent from the Columbia. In addition, a unique stickleback (*Gasterosteus* sp.) and a dace (*Rhinichthys* sp.) have similar distributions (McPhail 1967, 1969; Bisson and Reimers 1977). In contrast two Columbia species, *Rhinichthys falcatus* and *Percopsis transmontana*, are present in a Columbia tributary (the Cowlitz River) that is separated from the Chehalis by less than 10 km of low

terrain. In this area, tributaries of the two river systems often rise within a few hundred meters of one another. Yet these species are absent from the Chehalis system. Such faunal differences argue that despite their close proximity, the two river systems have been isolated for a long time, and that they have not exchanged species in recent time. With the exception of *Novumbra*, all of the forms unique to western Washington have sister species in the Columbia. Presumably, the Chehalis forms evolved as peripheral isolates of more widespread Columbia species during the period of isolation from the Columbia. This isolation still exists and the Salish Sucker, *Catostomus* sp., is one of these isolates.

Post-glacially, the Chehalis fauna dispersed north into formerly glaciated areas through a series of drainage connections and proglacial lakes that occupied the area that is now Puget Sound (Bretz 1913; Thorson 1980). The Fraser River was a Columbia tributary until its present outlet to the sea was established about 11 000 BC (Armstrong 1980). Not surprisingly, the Fraser contains Columbia fauna; however, it was only after the ice left the Fraser Canyon that the Columbia fauna was able to disperse downstream into the lower Fraser valley. In contrast, the Puget lowlands and parts of the lower Fraser valley were ice-free and above sea level by 12 000 BC (Easterbrook 1969; Armstrong 1980). Thus, the Salish Sucker (Figure 1) and other Chehalis forms were able to reach the lower Fraser Valley at least 1000 years before their sister species from the Columbia. Later (about 11 500 BC) the lower Fraser Valley was inundated by the sea up to an altitude of about 100 m.

*Endangered status approved and assigned by COSEWIC April 1986.



FIGURE 1. Salish Sucker (*Catostomus* sp.): an adult male (133 mm) from the lower Fraser Valley, British Columbia.

Presumably, any populations of freshwater fish below this altitude were destroyed. This explains the peculiar distribution of the Salish Sucker in the lower Fraser Valley (Figures 2 and 3). It is confined to areas that were post-glacially open to invasion from the south but were high enough (above 100 m) to escape this last post-glacial marine submergence.

Distribution

The range of this sucker is restricted to the Puget Sound region of Washington State (Figure 2) and the adjoining southwest corner of the lower Fraser Valley in British Columbia. In Canada, it is found only in the headwaters of the Campbell† and Salmon rivers and in Bertrand, Pepin and Salwein creeks (Figure 3).

Protection

International

Although the existence of a morphologically distinctive sucker on the Olympic Peninsula has been known since 1947 (Schultz 1947), this fish has never been described. Thus, it is not officially protected; however, both known Washington populations appear to be in no danger. The Lake Cushman population is adjacent to the Olympic National Park and partly included in a U.S. National Forest. Although Lake Cushman is a reservoir, there is no development in the area. The other known Washington population (Upper Twin Lake, Snohomish County) is also adjacent to a U.S. National Forest and there is restricted access in the area due to a

military installation. There are probably other populations in Washington (particularly in the Nooksack system to which Bertrand and Pepin creeks are tributary).

National

The Salish Sucker is not listed as an endangered species in British Columbia; however, it receives some incidental protection, as do all other fish, through the fish habitat sections of the Fisheries Act.

Population Size and Trends

The Salish Sucker was common in suitable sections of the Campbell and Salmon rivers during the 1950s. With increasing urbanization, however, it appears to be destined for extinction in British Columbia. The last specimens collected from the Campbell River were taken in the mid 1960s. The last individual seen, but not collected, was recorded in 1976. Since 1976, the only known spawning site on the Campbell River has been surveyed repeatedly, but no further specimens have been observed. During April and May 1983, a concerted effort was made to collect this sucker in the Campbell River. Baited minnow traps were set overnight at all localities where this sucker was previously known to occur. In addition, traps were scattered in suitable habitats throughout the headwaters of the Campbell River. No suckers were collected. These same areas were then electro-shocked and seined with the same negative result. It seems likely that this species is now extirpated in the Campbell River.

Within the Salmon River drainage system the area used by this sucker has also declined dramatically. The Salish Sucker no longer occurs in sections of the river where it was once common. It now appears to be

†The map name of this stream is the Campbell River; however, this name is almost never used. The local name is the Little Campbell River.

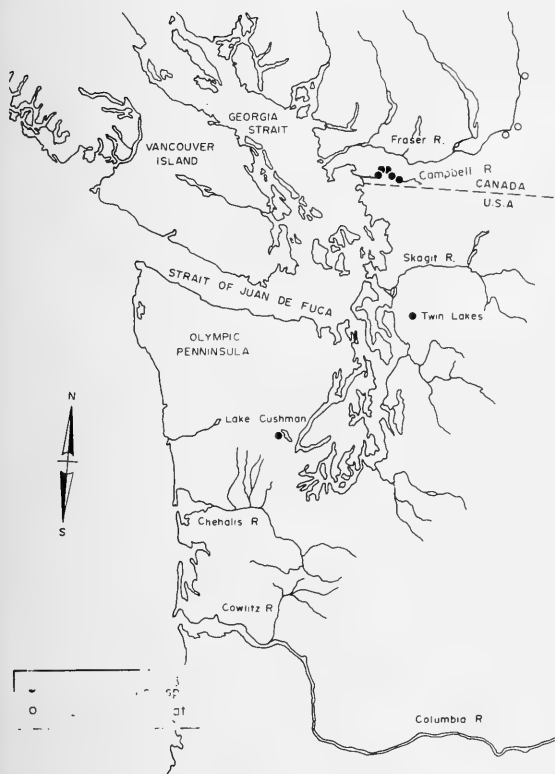


FIGURE 2. The known geographical range of the Salish Sucker, *Catostomus* sp.

- *Catostomus* sp.
- *Catostomus catostomus*

restricted to the extreme headwaters. Spawning individuals were observed in a small stream less than a kilometer from Aldergrove in 1980. In 1981, the stream was ditched and the site was not used for spawning in either 1982 or 1983. During the spring of 1983, all headwater streams in the Salmon system were examined and a spawning site was located where the river crosses Le Feuvre Road in Matsqui Municipality. This site is 1.1 km upstream of the previously known site. It was the only spawning site located in the Salmon system. The river here is less than 2 m wide and rarely over 20 cm deep. By late June, the area upstream is reduced to a trickle. It is unlikely that any successful spawning occurs above this site. The spawning population contains less than 100 adults. Thus, although the Salish Sucker is still extant in the Salmon River, its numbers are greatly reduced.

In 1981, the species was recorded from Bertrand Creek near Aldergrove (Figure 3). In 1983, Bertrand

Creek was surveyed but no adult suckers were located. However, four juveniles were collected (and returned to the water alive) from a small tributary of Bertrand Creek, 1.9 km southwest of Aldergrove. Bertrand Creek is a Nooksack tributary and flows south into Washington State. Although the headwaters of the main creek run through the town of Aldergrove and are badly polluted, many of the tributary streams are less urbanized. It seems likely that Bertrand Creek and its tributaries still contain modest populations of the Salish Sucker. A careful survey of the tributaries of the Bertrand Creek in March and April could uncover another spawning site.

Fishtrap Creek (another Nooksack tributary) rises in the town of Clearbrook (Figure 3). This stream was also surveyed, but is so badly polluted in its headwaters that in many places it contains no fish. A third and much smaller Nooksack tributary, Pepin Creek, was also surveyed. A small population of Salish Suckers was located in this creek where it crosses Bradner Road (Figure 3). Several adults in breeding colour were observed, but visibility was poor and numbers could not be estimated. Pepin Creek is less than 6 km long (in Canada), but it is largely unpolluted. It flows through a mostly undeveloped area, and at least half its length in Canada is in Aldergrove Lake Park. Of the populations of this sucker still extant in British Columbia, it is likely that the Pepin Creek population is the least threatened.

In 1984, another Salish Sucker population was discovered in Salwein Creek, a Vedder River tributary (Figure 3). This population is located 40 km east of the other Canadian populations. Streams to the east and west of Salwein Creek were intensively sampled, but no further populations were located. Future surveys are planned for the 45 km area that now separates the ranges of the Longnose and Salish suckers in the Fraser Valley.

Habitat

In British Columbia, the Salish Sucker is confined to small, lowland streams in the lower Fraser Valley. Within these streams it occurs most abundantly in headwater areas. These areas tend to have slightly cooler summer water temperatures and slightly higher average gradients than lower areas in the same streams. In the lower Fraser Valley the amount of suitable habitat is declining rapidly, and what is left is subject to a high risk of accidental pollution from urban activities.

The known Washington populations are in lakes. One, Lake Cushman, is a large oligotrophic reservoir, whereas the other (Upper Twin Lake) is a small lake situated at about 300 m elevation.

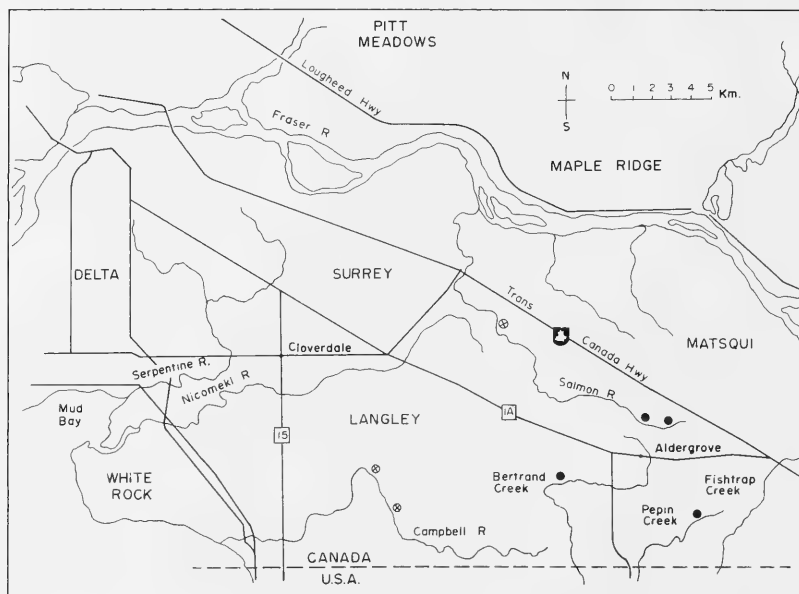


FIGURE 3. The Canadian distribution of the Salish Sucker, *Catostomus* sp.

- Extant Populations
- ⊗ Extirpated Populations

General Biology

There is no published summary of the biology of the Salish Sucker and what follows are my observations. The British Columbia populations are smaller in body size than the Washington populations. In the Campbell River the largest known specimen is 140 mm in standard length, and in the Salmon River the largest specimen is 15 mm. In Washington, the species regularly reaches lengths of 200 mm.

In British Columbia the smallest sexually mature males were in their third year (about 120 mm in length), whereas the smallest mature females were in their fourth year (about 145 mm). No individuals older than five years are known from British Columbia, but some Washington specimens were at least six years old. These ages are based on scale readings, and thus, may be underestimated (Beamish and Harvey 1969).

This sucker spawns in the early spring. In Washington it has been observed spawning in March (Upper Twin Lake, 9 March 1965; water temperature 7°C). In the Salmon River, spawning was observed on 10 April 1980; water temperature was 8°C. During 1983, it was observed spawning in the Salmon River (6 April; water temperature 8°C) and in Pepin Creek (14 April; water temperature 7°C). The spawning sites were riffles containing fine gravel. No estimates of

fecundity are available, but preserved females contain large numbers of small eggs, and the fecundity is probably similar to the Longnose Sucker. The spawning colours and sexual dimorphism are similar to those described for the Longnose Sucker (Scott and Crossman 1973).

The diet of adults appears to consist largely of chironomid larvae: the guts of ten adults all contained detritus plus a large number of chironomid head-capsules. The diet of the young is unknown.

In British Columbia the species typically co-occurs with juvenile Coho Salmon, *Oncorhynchus kisutch*, Cutthroat Trout, *Salmo clarki*, and Prickly Sculpin, *Cottus asper*. All three of these species are capable of being significant predators on the newly-hatched young and juveniles of the Salish Sucker.

Limiting Factors

In British Columbia the main limiting factor appears to be suitable habitat. As the area around Langley and Aldergrove becomes increasingly urban, the streams that support this species are changing. The riparian vegetation is shifting from alder, *Alnus* sp., bush to pasture and domestic lots. Summer water temperatures are increasing and summer flow decreasing. The streams are prone to flash flooding, and thus are increasingly subject to ditching and other

control measures. Since the small headwater tributaries used by this species for spawning are not important trout or salmon habitat, there is little concern in fisheries agencies (either federal or provincial) about such environmental alterations.

Special Significance

This species is part of the Chehalis fish fauna. McPhail (1967) described the history of this fauna. It evolved in the unglaciated area south of the Puget Ice-lobe and north of the Columbia River. The fauna contains an endemic genus (*Novumbra*) and a number of morphologically distinctive, but undescribed, species with closely related Columbia counterparts. The Salish Sucker and a dace (*Rhinichthys* sp.) are the only components of this unique fauna that occur in Canada. Because of its presence in the Campbell River system the species has been referred to as Campbell Sucker, but Salish Sucker is preferable since the name is more descriptive of the overall area of distribution.

Within the genus *Catostomus*, the Salish Sucker clearly belongs in the subgenus *Catostomus*: it has a well developed frontoparietal fontanelle and a relatively short gut (1.5 to 2.5 times standard length). In general morphology and breeding colour, it is more similar to *C. catostomus* than to any other *Catostomus* species in the Fraser or Columbia systems. The Salish Sucker differs from *C. catostomus* primarily in body proportions and scale counts. In the Salish Sucker the scales are larger, the head deeper and the snout shorter than in *C. catostomus* (Table 1; Figure 1).

Since the Salish Sucker and *C. catostomus* are allopatric, it is impossible to determine if they are

reproductively isolated, and any decision on the taxonomic status of the Salish Sucker must be based on morphology alone. Because these forms overlap in all counts and measurements, the decision rests on the relative degree of their differences. Until a review of morphological variability in the Longnose Sucker is completed this question can not be resolved.

One solution is to name the Salish Sucker as a subspecies of *C. catostomus*. Unfortunately, it is clearly not a subspecies in the "normal" sense. In fishes, subspecies typically have geographic ranges connected by a zone of introgression (Bailey et al. 1954). The Longnose and Salish suckers occur in distinct geographic areas. The ranges of the two forms only come close together in the lower Fraser Valley (Figure 2). In this region they are separated by 90 km of river. There is, however, no physical barrier separating them, and if gene flow has occurred between the two forms, then the Fraser Valley populations should show signs of this gene exchange. From Tables 1 and 2, it is clear that the Fraser Valley populations of both *C. catostomus* and the Salish Sucker are as distinct from one another as are totally allopatric populations. This suggests that there has been no gene flow between the two forms in the Fraser Valley. Consequently, these suckers represent lineages separated since at least the last glaciation, and the morphological differences between these lineages imply that they are on different and distinct evolutionary trajectories. As such, these suckers fit the evolutionary species concept (Wiley 1978) more comfortably than they fit the subspecies concept (Bailey et al. 1954).

Unfortunately, this does not answer the question of

TABLE 1. A morphometric and meristic comparison of northwestern *C. catostomus* and the Salish Sucker (measurements are standardized to 120 mm*).

Drainage System	Head Depth	Snout Length	Body Depth	Lip Width	Lateral Line Scales	Caudal Peduncle Scales
<i>Catostomus catostomus</i>						
Fraser (N = 34)	15.3 ± 0.76	14.0 ± 0.75	23.3 ± 1.35	4.43 ± 0.50	106.1 ± 5.83	28.6 ± 1.58
Columbia (N = 53)	14.9 ± 0.79	14.0 ± 0.75	23.2 ± 1.13	4.18 ± 0.51	102.8 ± 6.7	27.1 ± 1.30
Yukon (N = 21)	14.0 ± 0.55	13.9 ± 0.49	22.0 ± 1.44	4.83 ± 0.51	110.1 ± 5.16	28.1 ± 1.41
<i>Catostomus</i> sp.						
Campbell Twin and Cushman (N = 26)	16.0 ± 0.56	12.4 ± 0.71	24.6 ± 1.48	2.89 ± 0.33	86.1 ± 0.33	23.3 ± 1.02

*120 mm represents the grand mean of standard length for all the samples examined.

TABLE 2. A morphometric and meristic comparison of *Catostomus catostomus* from the Fraser River and tributaries near Hope, British Columbia, and the Salish Sucker from a Fraser tributary (the Salmon River) near Langley, British Columbia. (Measurements are standardized to 120 mm.)

Drainage System	Head Depth	Snout Length	Body Depth	Lip Width	Lateral Line Scales	Caudal Peduncle Scales
<i>Catostomus catostomus</i>						
Hope area	15.0 ± 0.65	14.0 ± 0.78	23.2 ± 0.82	4.36 ± 0.48	107.1 ± 3.22	29.0 ± 1.34
<i>Catostomus</i> sp.						
Salmon River (N = 10)	16.1 ± 0.53	12.2 ± 0.68	25.1 ± 1.38	2.80 ± 0.28	84.2 ± 2.45	23.3 ± 1.00

whether the Salish Sucker is morphologically distinct enough to warrant taxonomic recognition. Again, this question cannot be answered without an extensive study of the Longnose Sucker. For now, it is perhaps best to recognize the Salish Sucker as a peripheral isolate of a widespread species, *C. catostomus*. This in no way diminishes its scientific importance or unique status. Although a peripheral isolate, the Salish Sucker represents something different from single, isolated populations. It is a distinctive form, made up of many populations, and has a considerable geographic range and a unique evolutionary history. Indeed, it can be considered a "species" in the making and as such deserves as much protection as formally recognized species.

Evaluation

The main reason for the decline in this sucker is clearly habitat change, particularly in headwater areas. Nothing will prevent the further urbanization of this region, and the best that can happen is that parks will include enough natural habitat to maintain this unique sucker. Otherwise, this unique form is destined for extinction.

Acknowledgments

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Literature Cited

- Armstrong, J. E. 1980. Post-Vashon Wisconsin glaciation, Fraser Lowland, British Columbia. Geological Survey of Canada Bulletin 322.
- Bailey, R. M., H. E. Winn, and C. L. Smith. 1954. Fishes from the Escambia River, Alabama and Florida, with ecological and taxonomic notes. Proceedings of the Academy of Natural Sciences, Philadelphia 105: 109-164.
- Beamish, R. J., and H. H. Harvey. 1969. Age determination in the white sucker. Journal of the Fisheries Research Board of Canada 26: 633-638.
- Bisson, P. A., and P. E. Reimers. 1977. Geographic variation among Pacific Northwest populations of Longnose dace, *Rhinichthys cataractae*. Copeia 1977(3): 518-522.
- Bretz, J. H. 1913. Glaciation of the Puget Sound Region. Washington Geological Survey Bulletin 8.
- Easterbrook, D. J. 1969. Pleistocene chronology of the Puget Lowland and San Juan Islands, Washington. Geological Society of America Bulletin 80: 2273-2286.
- Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh. Biological Survey Publication Number 1980-12.
- McPhail, J. D. 1967. Distribution of freshwater fishes in western Washington. Northwest Science 41: 1-11.
- McPhail, J. D. 1969. Predation and the evolution of a stickleback (*Gasterosteus*). Journal of the Fisheries Research Board of Canada 26: 3183-3208.
- Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
- Schultz, L. P. 1947. A fine-scaled sucker, *Catostomus*, from Lake Cushman, Washington State. Copeia 1946(2): 202.
- Thorson, R. M. 1980. Ice-sheet glaciation of the Puget Lowland, Washington, during the Vashon Stage (Late Pleistocene). Quaternary Research 13: 303-321.
- Wiley, E. O. 1978. The evolutionary species concept reconsidered. Systematic Zoology 27: 17-26.

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Status of the Gravel Chub, *Hybopsis x-punctata*, in Canada*

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Parker, B., and P. McKee. 1987. Status of the Gravel Chub, *Hybopsis x-punctata*, in Canada. *Canadian Field-Naturalist* 101(2): 237-240.

The Gravel Chub, *Hybopsis x-punctata*, is endangered and may be extirpated in Canada. It has been reported only from the Thames River drainage of southern Ontario at the northeastern fringe of its North American range. The last record was in 1958 despite recent efforts to capture specimens. Siltation is the most likely factor affecting its distribution and survival. The Gravel Chub is not specifically protected in Canada, although general protection is afforded through the fish habitat section of the Fisheries Act.

Le gravelier, *Hybopsis x-punctata*, est une espèce qui est en danger d'extinction ou peut-être de déraninement au Canada. Il n'était présent que dans le bassin de la rivière Thames dans le sud de l'Ontario, à la limite nord-est de son aire de répartition en Amérique du Nord. Depuis 1958, aucun spécimen n'a été capturé malgré les efforts récents. L'envasement est probablement le facteur principal qui nuit à sa répartition et à sa survie. Le gravelier ne bénéficie pas d'une protection particulière au Canada, mais il est protégé de façon générale en vertu de l'article sur la protection de l'habitat du poisson de la Loi sur les pêcheries.

Key Words: Gravel Chub, *Hybopsis x-punctata*, endangered, population size and trend, cyprinids, Ontario.

The Gravel Chub, *Hybopsis x-punctata*, is a small cyprinid (Figure 1) seldom exceeding 7.6 cm in length. They are rare throughout their range in east-central North America where they are usually found in slow moving, deep, gravel-bottomed streams. This minnow is too rare to be of economic significance or widely known. Very little information is available on the biology and habits of these fish.

Distribution

The range of the Gravel Chub is large but discontinuous in east-central North America. In Canada, this species is recorded only from the Thames River drainage of southwestern Ontario, approximately 300 km from the nearest American records in Ohio (Figure 2). Ontario populations have been assigned to the subspecies *H. x-punctata trautmani* by Hubbs and Crowe (1956).

Protection

International

The Gravel Chub is considered endangered in Kansas (Platt 1974) and endangered status has been recommended in Wisconsin (Anonymous 1979). Gilbert (1980) reported it as now extirpated from many localities where it was formerly found in the United States.

National

This species is not protected in Canada, although fish habitat sections of the Fisheries Act do afford general protection.

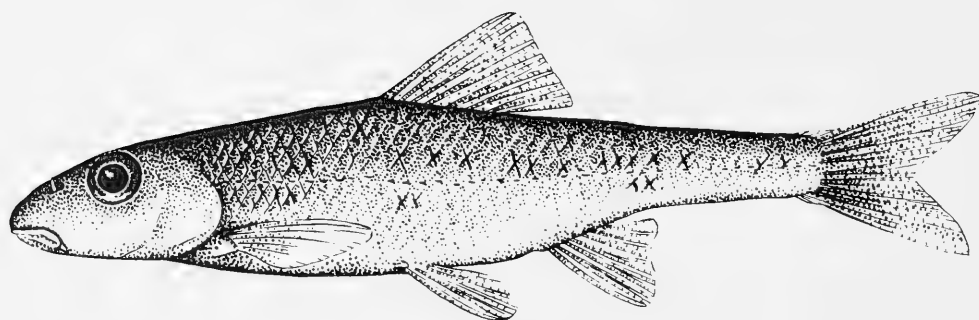
Population Size and Trends

The Gravel Chub has been reported at only two localities in Canada (Figure 3): the Thames River at Muncey Indian Reserve, Middlesex County (42° 50'N, 81° 30'W) in 1929 and in the North Thames River in London (43° 00'N, 81° 16'W) in August 1958. Attempts to collect this species in the early 1970s by the National Museum of Natural Sciences and the Ontario Ministry of Natural Resources were unsuccessful, as were the efforts of B. Parker and P. McKee in 1979-80 (Parker and McKee 1980). The scarcity of collected material suggests that populations were localized. The failure of recent attempts specifically directed at collecting this species seems to confirm earlier doubts about the continued existence of Canadian populations (Scott and Crossman 1973). McAllister and Gruchy (1977) listed the Gravel Chub as endangered in Canada.

Habitat

In Ontario, the Gravel Chub inhabited sections of the Thames River. Present conditions at capture sites are as follows. The river has a constant flow, is 20 to 30 m in width and 1 to 3 m in depth with pool and riffle habitats predominating. Substrate material is composed of sand, rock and stone with areas of soft

*Endangered status approved and assigned by COSEWIC 2 April 1985.



B

FIGURE 1. Gravel Chub, *Hybopsis x-punctata* (from Scott and Crossman 1973).



FIGURE 2. Canadian distribution of the Gravel Chub.

Evaluation

Populations of this species have only been reported from the Thames River drainage in Canada; the last specimens were caught in 1958. There is no recent evidence of reproducing populations in Canada. The Gravel Chub was at the northeastern fringe of its North American range in Canada. Canadian populations provide the only evidence for this species' existence in the Great Lakes basin.

As this species is believed to be particularly sensitive to environmental deterioration in the form of siltation, it may be important as a pollution indicator. However, the waters in which the species is found are difficult to inventory, and despite the failure of current collection efforts and the 29 years since the last collected specimen, it may be premature to designate the species extirpated in Canada. It is recommended that it be considered endangered.

Acknowledgments

This paper is based on Parker and McKee (1980). The assistance given by the Ontario Ministry of Natural Resources, the Royal Ontario Museum and the National Museum of Natural Sciences is appreciated. Funding was supplied through the Department of Supply and Services, the Department of Fisheries and Oceans, and the National Museum of Natural Sciences.

Literature Cited

- Anonymous.** 1979. Wisconsin ups its protection of native animals and plants. *Endangered Species Technical Bulletin* 4(1): 7-12.
- Cross, F. B.** 1967. *Handbook of fishes of Kansas*. University of Kansas Museum of Natural History Miscellaneous Publication 45: 1-357.

- Davis, B. J., and R. J. Miller.** 1967. Brain patterns in minnows of the genus *Hybopsis* in relation to feeding habits and habitat. *Copeia* 1967 (1): 1-39.
- Gilbert, C. R.** 1980. Gravel Chub, *Hybopsis x-punctata*. In *Atlas of North American freshwater fishes*. Edited by D. S. Lee, C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAlister, and R. J. Stouffer, Jr. North Carolina State Museum of Natural History, Raleigh, North Carolina. Biological Survey Publication 1980-12.
- Hubbs, C. L., and W. R. Crowe.** 1956. Preliminary analysis of the American cyprinid fishes, seven new, referred to the genus *Hybopsis*, subgenus *Erimystax*. *Occasional Papers of the Museum of Zoology, University of Michigan* 578.
- McAllister, D. E., and C. G. Gruchy.** 1977. Status and habitat of Canadian fishes in 1976. Pages 151-157 in *Canada's threatened species and habitat*. Edited by T. Mosquin and C. Suchal. Canadian Nature Federation Special Publication 6.
- Moore, G. A., and J. M. Paden.** 1950. The fishes of the Illinois River in Oklahoma and Arkansas. *American Midland Naturalist* 44(1): 1-83.
- Parker, B., and P. McKee.** 1980. Rare, threatened and endangered fishes in southern Ontario: Status reports. A report for the Department of Supply and Services, Department of Fisheries and Oceans, and National Museum of Natural Sciences. Beak Consultants Limited, Mississauga, Ontario.
- Pflieger, W. L.** 1975. The fishes of Missouri. Missouri. Department of Conservation, Jefferson City, Missouri.
- Platt, D. R.** 1974. Rare, endangered and extirpated species in Kansas. *Transactions of the Kansas Academy of Science* 76: 97-106.
- Scott, W. B., and E. J. Crossman.** 1973. *Freshwater fishes of Canada*. Fisheries Research Board of Canada Bulletin 184: 1-966.
- Trautman, M. B.** 1957. *The fishes of Ohio with illustrated keys*. Ohio State University Press, Columbus, Ohio.

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Status of the Longjaw Cisco, *Coregonus alpenae*, in Canada*

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The Longjaw Cisco was once abundant throughout the deeper areas of lakes Michigan and Huron and a small population also existed in Lake Erie. A single specimen from Georgian Bay in 1975 is the sole collection since 1968. The species is now presumed to be extinct. These fish probably inhabited the deep waters, preferring depths of 90–110 m. Spawning occurred in shallower waters (20–45 m) in October to November. The demise of *Coregonus alpenae* was likely due to overfishing and the Sea Lamprey, *Petromyzon marinus*, predation that accompanied the disappearance of the Lake Trout, *Salvelinus namaycush*. The reduction of all cisco populations in the Great Lakes by intensive fishing may have promoted introgressive hybridization in Great Lakes ciscos and furthered the elimination of *C. alpenae*.

Le cisco à grande bouche était jadis abondant dans toutes les eaux profondes des lacs Michigan et Huron et une petite population vivait également dans le lac Érié. À l'exception d'un seul spécimen provenant de la baie Géorgienne en 1975, aucun individu n'a été capturé depuis 1968. On présume que l'espèce est maintenant éteinte. On estime que ces poissons habitaient les eaux profondes du lac, préférant des profondeurs de 90 à 110 m. La fraie avait lieu d'octobre à novembre dans des eaux peu profondes (20 à 45 m). La disparition de *Coregonus alpenae* est fort probablement due à une surpêche intensive et à la prédation par la lamproie marine (*Petromyzon marinus*) qui a accompagné la disparition du touladi (*Salvelinus namaycush*). Les contraintes subies par les populations de cisco des Grands lacs, en raison d'une forte pression de pêche, peuvent avoir conduit également à une différenciation morphologique du cisco des Grands lacs et contribué à la disparition de *C. alpenae* par le biais de l'hybridation introgressive.

Key Words: Ciscos, Longjaw Cisco, *Coregonus alpenae*, chub, Lake Huron, Lake Michigan, Ontario.

The Longjaw Cisco, *Coregonus alpenae* (Figure 1), had a slender, compressed body with an average length of 26.7 to 30.5 cm and an average adult weight of about 0.5 kg, although some may have been slightly longer (38 cm) and heavier (0.9 kg). The head was heavy, broad and short, and the eyes large. The lower jaw was heavy and usually projected beyond the upper jaw, giving rise to the common name applied to this fish. The overall coloration was silvery with a pink or purple iridescence. The back was green or blue, the sides silvery and the ventral surface white. Some individuals showed light pigmentation on the jaws. Nuptial tubercles were present on breeding males.

Distribution

The Longjaw Cisco was indigenous to the Great Lakes basin (Figure 2) and occurred in the waters of lakes Huron and Michigan (Scott and Crossman 1973). A small population may have existed in Lake Erie (Scott and Smith 1967) but was presumed extirpated there by 1970 (Scott and Crossman 1973). The species was last reported from Lake Michigan in 1968 and from Georgian Bay in 1975 (Todd 1980).

None have been reported in commercial catches since 1967 and the species is presumed extinct.

Protection

Coregonus alpenae was listed as an endangered species under the U.S. Endangered Species Act of 1973 and international trade was restricted by listing on Appendix I to the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). The species was delisted in 1983, since it was considered extinct. The species had been protected and managed in Canada under the Ontario Fishery Regulations of the Fisheries Act since 1898. Similar legislation existed in the USA where regulations controlled net size, minimum legal size for fish, and open and closed periods for the fishery, but these were not strictly enforced. Also, management strategies did not take into account the local nature of populations, their partial isolation, and their genetic distinctiveness.

Population Size and Trends

The deepwater ciscos, included with other species in the subgenus *Leucichthys* and known commercially as chubs, supported a commercial fishery in the Great Lakes that began in the mid-1800s. Records from this time into the early 20th century, where they exist, are inaccurate. Records from 1926 to 1939 are complete

*Extinct status approved and assigned by COSEWIC 2 April 1985.

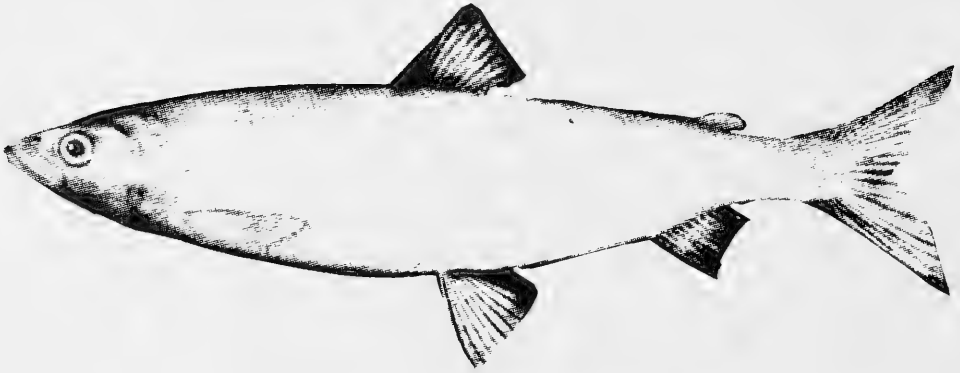


FIGURE 1. Longjaw Cisco, *Coregonus alpenae*.

for Lake Michigan (Smith 1964) but similar data was not kept for lakes Huron and Erie. The history of the larger, deepwater species *C. nigripinnis*, Blackfin Cisco, *C. johannae*, Deepwater Cisco, and the Longjaw Cisco suggests that the earliest fishery (Hile and Buettner 1955) was with gillnets with meshes greater than 7.6 cm. As the numbers of these larger fish declined, mesh sizes were decreased to maintain the catch rates and the smaller species, such as the Bloater, *C. hoyi*, the Shortnose Cisco, *C. reighardi*, and the Shortjaw Cisco, *C. zenithicus*, became more abundant in the catch and increased in importance to the fishery. For a while, the removal of large numbers of Lake Trout, *Salvelinus namaycush*, relieved predation on the smaller fish and improved the latter's competitive position relative to the larger ciscos. The selective decline of Lake Trout, Burbot, *Lota lota*, and of large ciscos was intensified with the invasion of the upper lakes by the Sea Lamprey, *Petromyzon marinus*. The effort to take larger fish after the decline of the Lake Trout was reflected in increased production from 0.8 million kg in 1941 to 5 million kg in 1951 in Lake Michigan (Smith 1964). Prior to this period, *C. alpenae* had been an important contributor to the fishery, where their abundance represented up to 30% of the chub taken in the 1930s (Smith 1964). By the 1950s the Longjaw Cisco represented less than 1% of the catches and by the mid to late 1960s they had entirely disappeared from the fishery.

The Longjaw Cisco apparently was abundant throughout its range until the early 1900s. In the early decades of this century these fish increased in abundance and probably numbered in the millions in lakes Huron and Michigan but were less abundant in Lake Erie. The intensive fishery favouring larger fish, and decreased predation by Lake Trout, may have promoted their increase. By the mid-1950s, however,

the intensified fishing of even the smaller fish and predation by Sea Lamprey had seriously depleted *C. alpenae* populations. These stresses, and possibly introgressive hybridization, completed the demise of the Longjaw Cisco in the 1960s.

Habitat

The Longjaw Cisco was a deepwater cisco found at depths of 94-112 m in Lake Huron (Scott and Crossman 1973) and perhaps in deeper waters (128-177 m) in Lake Michigan (Jobes 1949). In Lake Erie, most of these fish were taken at depths of about 30 m (Scott and Smith 1962). In the fall, the fish moved to shallower waters of perhaps half that depth to spawn.

The morphological diversity of the ciscos suggest that populations were locally adapted and partly isolated and that these were differentially subject to exploitation and extinction (Todd et al. 1981). Lack of complete genetic isolation barriers between them has been demonstrated by the increasing number of hybrids that have appeared as a result of the breakdown of the ecological barriers (Smith 1964). Differences in spawning time and location once served to separate species and stocks, but were removed through the elimination of predators or some cisco stocks. Some forms, such as *C. hoyi*, then became so abundant that they spread throughout Lake Michigan and hybridized freely with populations formerly isolated from them. Subsequent introgressive hybridization removed the distinctions between them (Smith 1964). Pollution and other environmental modification may also have assisted in this genetic shift. The possible role of high DDT levels and other pollutants in the decline of certain species in the Great Lakes has never been adequately studied but cannot be dismissed.



FIGURE 2. Former distribution of the Longjaw Cisco.

General Biology

Spawning was thought to occur in November at depths of 18–46 m but may have been in deeper waters (Scott and Crossman 1973). The eggs were deposited on the bottom and abandoned, development occurring over the winter and hatching the following spring. The aggregation of the fish in large numbers during the fall spawning period made them extremely vulnerable to the fishery during this critical period. Fecundity studies on ciscos in the Great Lakes indicate that egg number is correlated with size: large females generally have more eggs (Scott and Crossman 1973) and a 30-cm female may have been capable of laying up to 20 000 eggs.

Growth rates of the Longjaw Cisco appear to have been fairly rapid, males and females growing at about the same rate (Scott and Crossman 1973). In lakes Michigan and Erie, fish attained lengths of 30 cm by age four and a weight of about 0.4 kg (Scott and Crossman 1973). Older individuals rarely attained a length of 38 cm or a weight of 1 kg (Koelz 1924). Sexual maturity was usually attained at the age of three to four years (Scott and Crossman 1973).

Benthic invertebrates such as *Mysis relicta* were apparently the principal food for this species and *Pontoporeia* may also have been important in their diet (Bersamin 1958). Small clams, invertebrates and aquatic insect larvae were also utilized (Koelz 1929). In turn, these fish were part of the food supply for the Lake Trout and Burbot before the decimation of the latter two species by the Sea Lamprey. The lamprey may have preyed on the Longjaw Cisco as well, especially after the decline of Lake Trout and Burbot (Scott and Crossman 1973).

The Longjaw Cisco appeared to be somewhat tolerant of the early fishery when the gillnets removed only larger fish and initially were more selective for the larger Deepwater and Blackfin ciscos. As these species declined in abundance, others seemed to increase in numbers. However, the reduction in mesh size allowed even smaller fish to be caught and, no doubt, few fish survived to reproductive age after this practice became general in the 1950s. As catches declined, fishing pressure became more intense in order to maintain quotas. The introduction of deepwater trawls was probably instrumental in the final demise of the remaining deepwater forms such as *C. alpenae*.

Limiting Factors

Initially, the abundance of the Longjaw Cisco may have been limited by the Lake Trout and Burbot and the abundance of the large deepwater ciscos *C. johannae* and *C. nigripinnis* (Scott and Crossman 1973). The removal of the latter two species through over-exploitation, and of the former two by the Sea Lamprey, may have led to increased abundance of *C. alpenae* during the first part of the 20th century (Smith 1964). However, continued extensive exploitation, and predation by the Sea Lamprey, undoubtedly led to serious population declines after 1950. Environmental changes brought about by pollution, coupled with the intensive fishery, may also have led to shifts in the abundance of other species, especially *C. hoyi*, which became abundant throughout the lakes at this time (and indeed the Bloater is still the mainstay of the chub fishery). The effects of increased abundance of such species as the Bloater may have led to the breakdown of the spatial isolating barriers and promoted hybridization which, in turn, may have contributed to the disappearance of the Longjaw Cisco through introgressive hybridization due to lack of their own species with which to spawn.

Special Significance of the Species

The Longjaw Cisco was one of the deepwater ciscos preferred by the smoked fish trade and was important in the chub fishery.

The ciscos are the most widely distributed, and taxonomically the most problematic, of all freshwater fishes of Canada. The genus contains some fourteen species and difficulties in identification arise from lake-to-lake variations in shape, size, growth rate, and other characteristics which may be directly influenced environmentally. Five species (i.e., the Deepwater Cisco, the Longjaw Cisco, the Shortnose Cisco, the Kiyi (*C. kiyi*) and the Bloater) are (or were) endemic to the Great Lakes, living in the deeper waters. In addition to the endemic deepwater species, the Blackfin Cisco and the Shortjaw Cisco also inhabited the deeper waters of the Great Lakes and, collectively, these seven species were referred to as chubs (Scott and Crossman 1973). All five endemic species have disappeared from Lake Michigan, the Deepwater Cisco from Lake Huron, the Blackfin Cisco, the Shortjaw Cisco and the Kiyi from Lake Ontario and the Longjaw Cisco is extinct. Only the Bloater is now present in sufficient numbers to supply the smoked fish trade.

Coincident with the loss of these species, new forms have appeared which differ morphologically from the original forms. Smith (1968) suggested that introgressive hybridization has been taking place, and in the absence of mates of the same species, rare species are hybridizing with the Bloater and the Lake Herring, *C. artedii*.

Evaluation

A status of extinct is suggested with the reservation that populations and individuals seen in the past may never have represented a distinct "species", but rather an ecological phenotype. Under changed conditions, a similar phenotype may reappear.

The Longjaw Cisco is now considered extinct in the United States (by State and Federal governments) and has been delisted by CITES. Illinois, Michigan and Wisconsin now have commercial harvest quotas for deepwater ciscos as a group in lakes Michigan and Huron. Harvest quotas have also been instituted for the group in Canadian waters of the Great Lakes starting in 1984 (Parker 1984).

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Literature Cited

- Bersamin, S. V.** 1958. A preliminary study of the nutritional ecology and food habits of the chub (*Leucichthys* spp.) and their relation to the ecology of Lake Michigan. Papers of the Michigan Academy of Science 43: 107-118.
- Hile, R., and H. J. Buettner.** 1953. Commercial fishery for chubs (ciscoes) in Lake Michigan through 1953. U.S. Fish and Wildlife Society Special Science Report on Fisheries Number 163.
- Jobs, F. W.** 1949. The age, growth and distribution of the longjaw cisco (*Leucichthys alpenae*) Koely, in Lake Michigan. Transactions of the American Fisheries Society 76: 215-247.
- Koelz, W.** 1924. Two new species of cisco from the Great Lakes. Occasional Papers of the Museum of Zoology, University of Michigan 146.
- Koelz, W.** 1929. Coregonid fishes of the Great Lakes. Bulletin of the U.S. Bureau of Fisheries Number 43. 1927.2, Document 1048: 297-643.
- Moffett, J. W.** 1957. Recent changes in the deep-water fish populations of Lake Michigan. Transactions of the American Fisheries Society 86(1956): 393-408.
- Parker, B.** 1984. Status report on the deepwater cisco *Coregonus johanna* (Wagner) in Canada. Status Report for the Committee on the Status of Endangered Wildlife in Canada. Canadian Wildlife Service, Ottawa.
- Scott, W. B., and E. J. Crossman.** 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
- Scott, W. B., and S. H. Smith.** 1962. The occurrence of the Longjaw Cisco (*Leucichthys alpenae*) in Lake Erie. Journal of the Fisheries Research Board of Canada 19: 1013-1023.
- Smith, S. H.** 1964. Status of the deepwater cisco population of Lake Michigan. Transactions of the American Fisheries Society 93: 155-163.
- Smith, S. H.** 1968. Species succession and fishery exploitation in the Great Lakes. Journal of the Fisheries Research Board of Canada 25: 667-693.
- Todd, T. N.** 1980. *Coregonus alpenae* (Koelz), Longjaw Cisco. Page 76 in Atlas of North American freshwater fishes. Edited by D. S. Lee, C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and R. J. Stouffer, Jr. North Carolina State Museum of Natural History, Raleigh, North Carolina. Biological Survey Publication Number 1980-12.
- Todd, T. N., G. R. Smith, and L. E. Cable.** 1981. Environmental and genetic contributions to morphological differentiation in ciscos (*Coregonidae*) of the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 38: 59-67.

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Status of the Blue Walleye, *Stizostedion vitreum glaucum*, in Canada*†

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The Blue Walleye, *Stizostedion vitreum glaucum*, also referred to as the Blue Pike in the commercial fishery or Blue Pickerel by anglers, formerly occurred in the waters of lakes Ontario and Erie and the lower Niagara River. These fish were distinct from the Yellow Walleye, *Stizostedion vitreum vitreum*, in colour, size, growth rate, spawning time and area, and other biological characteristics such as a preference for deeper, cooler waters. The decline and disappearance of the Blue Walleye from lakes Erie and Ontario was probably directly related to over-exploitation by a largely unregulated commercial fishery. Due to their abundance, the Blue Walleye was an important part of the fishery in Lake Erie and was also valued as a sport fish. It may also be possible that accelerated eutrophication of Lake Erie, due to agricultural and industrial pollution, may have added to the stress of exploitation and together lowered the reproductive isolating barrier between the blue and yellow forms, with subsequent loss of distinctiveness of the Blue Walleye.

Le doré bleu, *Stizostedion vitreum glaucum*, appelé également “brochut bleu” par la pêche commerciale ou “varion bleu” par la pêche sportive, se rencontrait jadis dans les eaux des lacs Érié et Ontario ainsi que dans la basse du rivièrè Niagara. Ce poisson constituait une sous-espèce du doré jaune, *Stizostedion vitreum vitreum*, et s’en distinguait par la couleur, la taille maximale, le rythme de croissance, l’époque de la fraie, ainsi que par la région habitée et d’autres caractères biologiques tels que la préférence pour des eaux plus profondes et plus froides. Le déclin, puis la disparition du doré bleu des lacs Érié et Ontario étaient probablement liés directement à la sur exploitation due à une pêche commerciale en grande partie non réglementée. En raison de son abondance, le doré bleu constituait une partie importante de la pêche, spécialement au lac Érié, et il était également apprécié comme poisson de sport. Il est aussi possible que l’eutrophication accélérée du lac Érié, causé par la pollution agricole et industrielle, puisse avoir ajouté au stress de l’exploitation et puisse avoir fourni les moyens d’abaisser la barrière d’isolement reproducteur entre les formes bleue et jaune, entraînant ultérieurement à la déségrégation possible et la désintégration génétique du doré bleu.

Key Words: Blue Walleye, Blue Pike, Blue Pickerel, extinct species, *Stizostedion vitreum*, walleye, Ontario.

The Blue Walleye, *Stizostedion vitreum glaucum*, commonly referred to as Blue Pike or Blue Pickerel, was an elongated, robust fish (Figure 1) which resembled the Yellow Walleye, *Stizostedion vitreum vitreum*, except for size and coloration. The Blue Walleye was smaller and grew more slowly than the yellow form, rarely exceeding 34 cm in length or 0.7 kg in weight. The yellow subspecies averages 48 cm in length and 0.8 to 2.6 kg in weight.

The jaws of the Blue Walleye contained strong, sharp teeth. The large and somewhat opaque eyes give the walleye its name since the opaque appearance is similar to that of blinded or “walleyed” domestic animals. The cheek was smooth and almost scaleless. The body was steel to slate blue on the dorsal surface, ice blue to silvery blue on the sides and silvery to white on the ventral surface. The pelvic fins were white.

Distribution

The Blue Walleye formerly occurred in both the Canadian and U.S. waters of lakes Ontario and Erie, and in the lower Niagara River (Figure 2). The Blue Walleye of Lake Ontario may have originated as a migrant from Lake Erie (Regier et al. 1969) and was found mainly in the western basin, although it was recorded as far east as the Bay of Quinte (Scott and Crossman 1973). The grey-blue forms reported from Lake Nipissing and other inland lakes in Ontario have been considered by some to be Blue Walleye, but they are largely indistinguishable from blue-grey mutants of the Yellow Walleye found in Lake Erie and elsewhere (Scott and Crossman 1973) and do not have the other characteristics of the Blue Walleye which separate it from the Yellow Walleye (D.E. McAllister, personal communication).

*Extinct status approved and assigned by COSEWIC 2 April 1985.

†The American Fisheries Society Common Names Committee has recommended the vernacular name Blue Pike rather than Walleye for this subspecies of the *Stizostedion* genus. As Trautman (1981) pointed out, this led to confusion. Like most Canadians, I have referred to the fish as Blue Walleye throughout this manuscript as I think it is unfortunate to link the name pike to a perch. The fish was traded as Blue Pike in the heyday of the commercial fishery and called Blue Pickerel by the anglers. I prefer Blue Walleye to create the counterpart to Yellow Walleye.

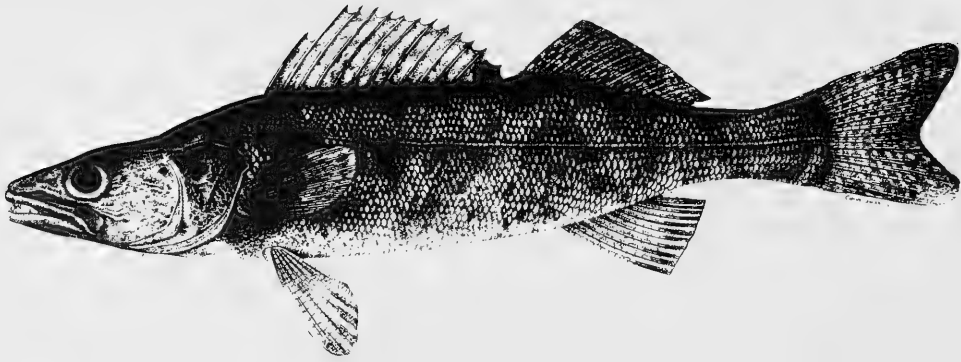


FIGURE 1. Blue Walleye, *Stizostedion vitreum glaucum*, Lake Erie at Port Crewe, Kent County, Ontario. Specimen 400 mm TL, 650 mm SL. ♂. 1.4 lb (preserved). Drawing by Celia Godkin (courtesy D. E. McAllister, National Museum of Natural Sciences.)

Blue Walleyes were abundant in lakes Erie and Ontario until the late 1900s, and by 1915, the population began to fluctuate extensively. The last confirmed specimen was taken from Lake Erie in 1965 (Anonymous 1983).

Protection

The Blue Walleye, as a sub-species of *Stizostedion vitreum*, received no special protective status in Canada or the United States. Walleye, including the blue form, were protected in Canada under the Ontario Fishery Regulations of the Fisheries Act since 1889. These regulations controlled net size, minimum capture size, and open and closed seasons for commercial and sport fishermen. However, from 1914 on, these regulations were not stringently enforced in lakes Erie and Ontario and from 1950 on the fishery was virtually unregulated (Regier et al. 1969). Similar legislation in the U.S. was in effect, dating from the 1930s, particularly in Ohio and Michigan, but, as in Ontario, the regulations were not enforced until 1966 following the collapse of the walleye populations in Lake Erie (Reiger et al. 1969). In 1970, the walleye fishery was closed in lakes Ontario and Erie due to mercury contamination and was not reopened until 1977.

Stizostedion vitreum glaucum was listed as endangered under the U.S. Endangered Species Act of 1973. It was listed by the Convention for International Trade in Endangered Species of Wild Flora and Fauna (CITES) under Appendix I, which prohibits international trade for commercial purposes in rare or endangered species. Since the fish is thought to be extinct, it was removed from CITES and the U.S. endangered list in 1983. The Blue Walleye is now beyond the need of protection, but if any individuals

were to be found, protection would be assured under the Fisheries Act.

Population Sizes and Trends

Until the 1950s, the Blue Walleye was abundant in Lake Erie and less so in Lake Ontario and the lower Niagara River. The Lake Ontario and Niagara River fish may have been migrants from Lake Erie (Regier et al. 1969). From 1850 until the collapse of the fishery in 1959, the species was of great economic importance to commercial fishermen, contributing up to one-fourth of the commercial catch. It was also highly valued as a sport fish and sport catches undoubtedly contributed substantially to the total catch.

Regrettably, statistics which would provide some indication of population size are either lacking or incomplete. However, commercial catch records for Lake Erie exist from 1915 until the collapse of the fishery. In Lake Ontario, the Blue Walleye were never as abundant as they were in Lake Erie and production was in the order of 1% of that in Lake Erie (Parsons 1967). Doan (1942), Van Oosten et al. (1954) and Parsons (1967) have shown that fluctuations in catch and availability of fish were in close agreement. Parsons (1967) felt that production statistics could be used, with some confidence, to judge changes in abundance. Fishing effort was fairly constant throughout this period, at least until 1950, when the Ontario gill net fishery commenced in earnest (Parsons 1967; Regier et al. 1969).

Smith and Snell (1981) showed that large catches were reported as early as 1850, and by 1895, Blue Walleye contributed some 3.6 million kg to the total fishery (lakes Erie and Ontario). At 0.4 kg average weight (Trautman 1981), this would mean some 9 million fish were harvested. Fishing mortality has

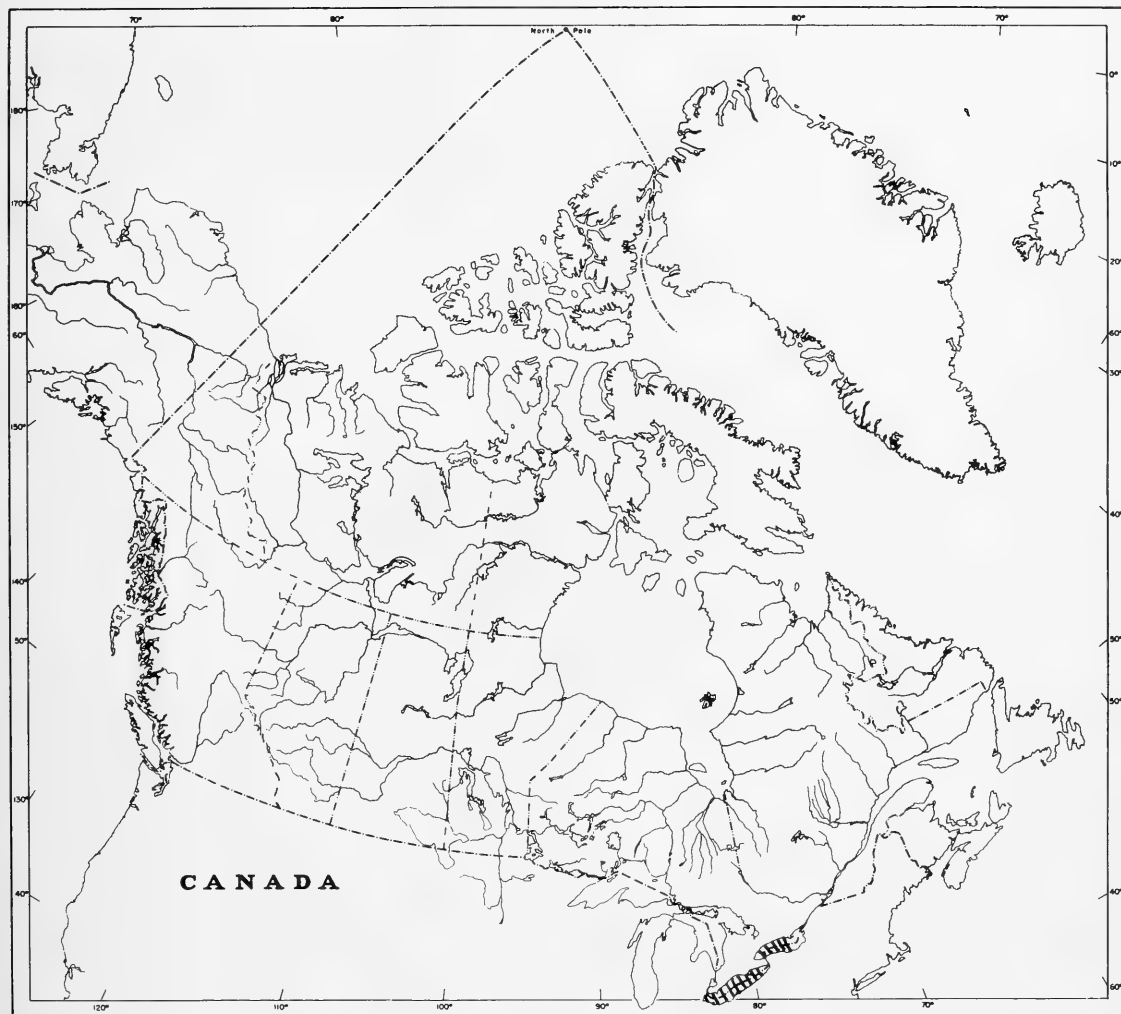


FIGURE 2. Former distribution of *Stizostedion vitreum glaucum*.

been estimated at 44% for yearlings and 78% for older fish (Regier et al. 1969). Blue Walleye were also highly sought in the recreational fishery. Prior to 1900, actual population numbers must have been well in excess of 50 million fish, of which probably 0.5 to 1 million were in the Niagara River and Lake Ontario.

Catch records for the Blue Walleye commercial fishery in Lake Erie from 1915 to 1959 (Table 1) show the fish to be abundant in Lake Erie until about 1910 when numbers began to fluctuate (Regier et al. 1969). In 1915, commercial production was nearly 11 million kg or about 27 million fish (Parsons 1967); this would indicate that the total population must

have exceeded 50 million. From 1916 to 1919 production declined to 900 000 kg, and by 1920-21 had increased to about 7 million kg and was fairly consistent through to 1926 with an average production of 6 million kg annually (Table 1). In 1927, catches began to decline again and by 1929 were down to about 3 million kg. Then, in 1929 and 1930, production jumped to 8 million kg and subsequently fell to 5 million kg in 1934 (Table 1). The peak production in 1936 of 12 million kg would indicate that the fish were once more abundant in numbers exceeding 50 million. Catches, however, fell yearly until 1941, reaching a low of 2 million kg, then

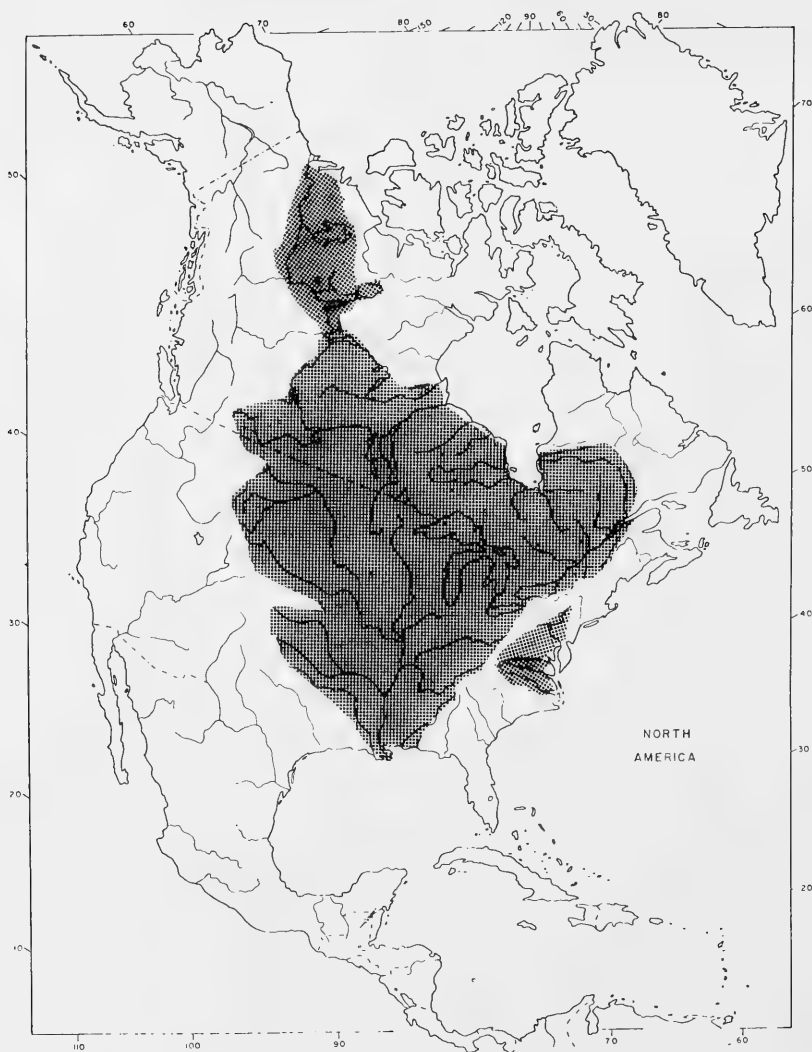


FIGURE 3. North American distribution of the Yellow Walleye, *Stizostedion vitreum*.

increased again to attain catches of 11 million kg in 1944 (Table 1). The oscillations which began in the 1910-1915 period with a five-year cycle clearly showed a shortening of the cycle from five to four to three to two years by 1948. From 1948 to 1959 the fluctuations were in alternate years, but production remained steady at over 6 million kg annually until 1957. In 1957, catches fell to about 4.5 million kg, and in 1958, to 600 000 kg. In 1959, the last year of the commercial fishery, the catch was only 350 000 kg.

Habitat

The habitat of the Blue Walleye overlapped that of the related subspecies, the Yellow Walleye, but areas of greatest abundance differed. These fish were most common in eastern Lake Erie, preferring deeper and cooler water than the Yellow Walleye (Parsons 1967). Walleye, including the blue form, are most successful in mesotrophic waters and are not tolerant of oligotrophic or eutrophic conditions (Regier et al. 1969). In Lake Erie (Regier et al. 1969) these fish

TABLE 1. Commercial production (thousands of pounds) of Blue Walleye in Lake Erie, 1915-59 (from Parsons 1967).¹

Year	United States				Canada	Lake Total
	Ohio	Pennsylvania	New York	Total	Ontario	
1915	13079	4796	866	18761	4882	23643
1916	7683	1408	298	9381	2539	11920
1917	1499	88	18	1605	566	2710
1918	1069	79	75	1222	785	2007
1919	1532	80	63	1675	2388	4063
1920	3499	302	169	3965	3355	7319
1921	5836	2741	367	8944	6367	15311
1922	7202	2593	565	10359	6313	16672
1923	6028	3013	642	9683	3194	12877
1924	5363	3077	527	8967	2988	11955
1925	4047	-	-	10478	3330	13808
1926	4234	2936	2170	9340	2975	12315
1927	4637	2190	475	7301	3078	10379
1928	3743	627	449	4819	2104	6923
1929	1803	713	305	2820	2538	5359
1930	9017	2211	564	11792	5898	17691
1931	7849	3690	1103	12643	5358	18001
1932	7784	1607	475	9867	3962	13829
1933	6735	1747	304	8786	4152	12938
1934	5765	2132	459	8356	2298	10654
1935	7142	2084	460	9686	5064	14750
1936	16478	2837	624	19909	6879	26788
1937	7020	2304	1638	10961	9355	20316
1938	6154	1442	1064	8659	7158	15817
1939	7263	1257	529	9049	5911	14960
1940	4541	313	97	4951	2012	6963
1941	3029	217	33	3287	1544	4831
1942	5296	824	98	6222	4405	10627
1943	8055	2364	809	11228	9614	20842
1944	11278	2129	1526	14933	9390	24323
1945	5167	1762	843	7772	6559	14331
1946	2550	351	111	3012	1909	4921
1947	2896	145	78	3120	1646	4766
1948	6957	1473	535	9003	5742	14745
1949	10616	2479	905	14000	9784	23783
1950	4900	1112	178	6190	8611	14801
1951	1867	174	109	2150	3914	23783
1952	5531	1081	158	6771	7267	14038
1953	6853	924	265	8042	10333	18375
1954	4576	1349	319	6245	8151	14396
1955	3679	2335	1634	7648	12037	19685
1956	4703	1231	921	6855	12002	18857
1957	2915	629	437	3981	6389	10370
1958	366	74	136	576	824	1399
1959	20	5	7	32	47	79

¹Data are from Baldwin and Saalfeld (1962). Records are not available for production in Pennsylvania and New York in 1925. Michigan production (included in U.S. and Lake Totals) was less than 500 except for the following years: 1941—8000 lb.; 1942—4000 lb.; 1946—1000 lb; and 1948—20000 lb.

seemed to prefer slightly turbid water (1-3 ppm, secchi disc reading of 1 to 3 m) due to their sensitivity to light. The eyes were large and the fish relied largely on sight to find prey (Regier et al. 1969), although the senses of touch, taste and smell were also important.

The Blue Walleye appeared to prefer cooler waters (15.6-21°C) and was less tolerant of low oxygen concentrations (Regier et al. 1969). In Lake Erie they were usually found in waters more than 13 m in depth over an even, hard bottom of sand or rock. They were

less numerous in shallow water during the summer and absent from turbid water. There was some movement of fish into shallower waters during the fall and winter (Trautman 1981). There is no data on preferred spawning locations, but like the Yellow Walleye, the Blue Walleye is believed to have preferred the boulder and coarse gravel areas of the lake. Intergrades between the blue and yellow forms occurred occasionally in rather large numbers in the commercial catch, particularly around the Bass Islands (Trautman 1981), indicating some overlap in spawning habitat. Trautman (1981) commented that the "grey" intergrades were usually considered to be hybrids between the Blue and Yellow walleye and were known to commercial fishermen in Ohio as "mules". E. J. Crossman (personal communication) has suggested that these may have simply been the "grey" form called "hards" by commercial fishermen in Ontario. Stone (1948) found that the blue and yellow forms differed in growth rate, minimum size, age at sexual maturity, location and time of spawning, and food habits.

Man's activities in the Great Lakes watershed have accelerated eutrophication. In Lake Erie, the relatively shallow depth and fertile drainage basin have made it the most productive of the Great Lakes. Agricultural, urban and industrial activity, particularly during the last few decades, increased the flow of nutrients into the lake. This has led to qualitative changes in plankton composition and production of excess organic matter. This surplus production settles to the bottom and its decomposition leads to oxygen depletion and a release of nutrients back to the water, thereby compounding the problem. Resultant increases in turbidity and low oxygen conditions have brought about a gradual shift in species composition to those which are more tolerant of pollutants and low oxygen concentration — these species are usually of less commercial value (Leach and Nepszy 1976).

Since 1974, through the efforts of the International Joint Commission (IJC), Canada and the United States have imposed bans and restrictions regulating nutrient loads (particularly of phosphorus) into the Great Lakes. Efforts have also been made to reduce the loadings of other contaminants such as mercury, which in 1970 led to a closure of commercial fishing in Lake St. Clair and of certain species such as walleye in lakes Erie and Ontario. These efforts have brought about a reduction in the rate of eutrophication of Lake Erie and some lessening of pollutant concentrations such as mercury. However, there is no indication of a return of species associated with oligotrophic conditions to the western or central basins.

The change in water conditions of the western basin may have forced the Blue Walleye into the deeper

waters of the eastern basin (Leach and Nepszy 1976) and perhaps into Lake Ontario, where they were more vulnerable to intensive fishing pressure. Eutrophication and the resulting shift in species density may have also effected Blue Walleye populations through competition and increased predation on eggs and young fish. The yearlings and older fish of species, such as the Yellow Perch, *Perca flavescens*, White Bass, *Morone chrysops*, Alewife, *Alosa pseudoharengus*, and Rainbow Smelt, *Osmerus mordax*, are effective predators on the pelagic young of walleye (Regier et al. 1969) and all of these became more prominent in the central and western basin with the increase in eutrophication.

General Biology

As abundant as these fish appear to have been and despite their importance in the commercial fishery, there is surprisingly little in the literature on their biology. In Lake Erie, spawning usually took place in May in shallow water. Spawning was thought to be later and in localities different from those of the Yellow Walleye (Scott and Crossman 1973). The spawning areas were presumably over rock, rubble or gravel in shallow offshore reefs. The enrichment of the traditional spawning areas may have led to decreases in hatching success in Lake Erie (Regier et al. 1969). Walleye have a high fecundity, having 30 000 to 300 000 or more eggs per female depending on size and other factors (Carlander 1950). The Blue Walleye being smaller (23.0 - 40.6 cm; 0.1 - 0.7 kg as opposed to 33.0 - 50.8 cm and 0.8 - 2.6 kg for Yellow Walleye) probably was not as fecund, and Carlander (1950) has indicated that one Lake Erie specimen at 32.4 cm contained 8170 eggs.

These fish apparently achieved breeding age between 30.5 and 33.0 cm (Scott 1967). Based on Deason's (1933) observations of Lake Erie fish, males appeared to mature earlier at two to three years of age (27.9 - 29.2 cm) and females at three to four years of age (30.5 - 33.0 cm). Deason (1933) also indicated a sex ratio of 45% males; this was fairly constant over all year-classes.

Limiting Factors

Regier et al. (1969) considered that extensive exploitation disrupted self-stabilizing mechanisms within the populations, leading to extreme fluctuations and the ultimate collapse of Blue Walleye populations. Legal size for the subspecies was 27.9 cm; thus, a large proportion of individuals were removed before reaching maturity. Over-fishing virtually extinguished most year-classes by age group IV, and age groups V and VI were virtually absent in commercial catches (Deason 1933; Parsons 1967).

Since young-of-the-year fish inhabited the same waters as older fish, they were vulnerable to cannibalism. Regier et al. (1969) indicated over-fishing of adults would cause large numbers of the younger fish to escape predation and cannibalism, leading to short explosions in population numbers followed by years of non-recruitment due to over-predation of abundant older fish on the young. Extensive fishing caused increased amplitude in the fluctuations, since fish were taken even when scarce.

Under better conditions of fishery management and an increase of the legal size to 34.3 cm, the Blue Walleye might have been saved. However, the introduction of Rainbow Smelt into Lake Erie no doubt increased inter-specific competition and predation on young fish (Regier et al. 1969). The eutrophication of Lake Erie may have caused changes in the oxygen depletion rate in the hypolimnion of the central basin, forcing the fish into the deeper water of the eastern basin where they were more vulnerable to fishing effort (Leach and Nepszy 1976). The inferred stress of anoxic water may have displaced the Blue Walleye into waters commonly frequented by the Yellow Walleye. There followed a breakdown of the reproductive isolation barriers, and genetic desegregation led to the ultimate demise of a population already under stress from over-fishing and pollution (Regier et al. 1969). The fact that these fish disappeared in Lake Ontario at about the same time may indicate that the Lake Ontario populations were indeed migrants or larvae washed down from Lake Erie or that over-exploitation alone was solely responsible for their demise.

That Lake Erie did not become too eutrophic for walleye can be inferred from the fact that the Yellow Walleye and the Sauger, *Stizostedion canadense*, still exist. The closure of the fishery in 1970 has improved the status of stocks (J. C. Tilt, personal communication) and large numbers are taken annually in the recreational fishery.

Special Significance of the Species

From the early part of the 19th century the Blue Walleye was of great economic importance in the commercial fishery and in the sport and recreational fishery as well.

The nomenclatural status of the Blue Walleye is typical of evolution of taxonomic knowledge. Hubbs (1926) originally described the Blue Walleye as a separate species *Stizostedion glaucum*, but the number of intergrades between the two walleyes led to the subspecific status (Trautman 1981). In aspects other than colour and eye size and position, the two subspecies were difficult to distinguish (Scott and Crossman 1973). Mutant grey-blue Walleye, *S. v.*

vitreum, are known outside the range of *S. v. glaucum* but they do not have the other characteristics of *S. v. glaucum* and do not cast doubt on the subspecies validity (D. E. McAllister, personal communication). D. E. McAllister (personal communication) also indicated that the existence of hybrid "grey walleye" in Lake Erie (Trautman 1981) showed that the distinctiveness of the Blue Walleye was not dependent on a single colour mutation. The fact that both subspecies occurred in lakes Erie and Ontario before the recent large scale stresses introduced by man suggests that the difference between the two taxa bordered on the species level. Regier et al. (1969) believed the two gene pools had remained discrete for "reasons other than simple spatial barriers," but that introgression followed environmental changes.

Evaluation

The Blue Walleye of lakes Erie and Ontario is probably extinct.

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Literature Cited

- Anonymous. 1983. Canadian proposal for amendments to Appendix I of CITES: Removal of the blue walleye from Appendix I. Canadian Document for the Convention on International Trade in Endangered Species, Canadian Wildlife Service, Ottawa.
- Baldwin, N. S., and R. W. Saalfeld. 1962. Commercial fish production in the Great Lakes 1867-1960. Great Lakes Fishery Commission Technical Report 3.
- Carlander, K. D. 1950. Handbook of freshwater fishery biology. Wm. C. Brown Co., Dubuque, Iowa.
- Deason, H. J. 1933. Preliminary report on the growth rate, dominance and maturity of the pike-perches (*Stizostedion*) of Lake Erie. Transactions of the American Fisheries Society 63: 348-360.
- Doan, K. H. 1942. Some meteorological and limnological conditions as factors in the abundance of certain fishes in Lake Erie. Ecological Monographs 12: 293-314.
- Hubbs, C. L. 1926. A checklist of the fishes of the Great Lakes and tributary waters with nomenclatorial notes and analytical keys. University of Michigan Museum of Zoology Miscellaneous Publication 15.

- Leach, J. H., and S. J. Nepszy.** 1976. The fish community in Lake Erie. *Journal of the Fisheries Research Board of Canada* 33: 622-638.
- Parsons, J. W.** 1967. Contributions of year-classes of blue pike to the commercial fishery of Lake Erie, 1943-1959. *Journal of the Fisheries Research Board of Canada* 24: 1035-1066.
- Regier, N. A., V. C. Applegate, and R. A. Ryder.** 1969. The ecology and management of the walleye in western Lake Erie. Great Lakes Fisheries Commission Technical Report 15.
- Scott, W. B.** 1967. Freshwater fishes of eastern Canada. Second edition. University of Toronto Press, Toronto, Ontario.
- Scott, W. B., and E. J. Crossman.** 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.
- Smith, H. M., and M. M. Snell.** 1891. Review of the fisheries of the Great Lakes in 1885 with introduction of fishing vessels and boats by J. W. Collins. Report of the U.S. Commission on Fisheries 1887: 1-333.
- Stone, F. L.** 1948. A study on the taxonomy of the blue and yellow pike-perches (*Stizostedion*) of Lake Erie and Lake Ontario. Ph.D. thesis, University of Rochester, Rochester, New York.
- Trautman, M. B.** 1981. The fishes of Ohio. Ohio State University Press, Columbus, Ohio.
- Van Oosten, J., R. Hile, and F. W. Jones.** 1946. The whitefish fishery of lakes Huron and Michigan with special reference to the deep trap-net fishery. Fisheries Bulletin, U.S. Fish and Wildlife Service 50: 297-394.

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Status of the Hooded Seal, *Cystophora cristata*, in Canada*

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Hooded Seals occur widely through the western North Atlantic during the pelagic feeding and non-breeding stages of their life cycle, but their breeding distribution is more limited. Three main breeding areas are known: the “West Ice” near Jan Mayen Island, the “Front” off Newfoundland, Labrador and the Gulf of St. Lawrence, and in Davis Strait. Population relationships between the breeding areas are not clearly known, but seals from the Front and Davis Strait are known to migrate into the coastal areas to the west and south of Greenland. To date the West Ice stocks have not been linked with the Davis Strait or Front stocks. Population declines following heavy exploitation from the 1950s through the 1970s were suspected; however, the lack of adequate population estimates left this somewhat in doubt. Recent aerial/ground surveys conducted on the Front and Davis Strait stocks suggest that the population may be increasing. Hooded Seals are not in jeopardy in Canada.

Les phoques à capuchon se dispersent largement pour s'alimenter dans les profondeurs de l'Atlantique nord-ouest en dehors de la saison d'accouplement, mais leur distribution est plus restreinte en période de reproduction. On connaît trois aires de reproduction principales: la région que les Norvégiens appellent la “banquise de l'ouest” près de l'île Jan Mayen, la région du Front au large de Terre-Neuve et du Labrador et le golfe Saint-Laurent, et le détroit de Davis. On ne connaît pas vraiment les liens existants entre les populations des aires de reproduction, mais on sait que les phoques de la région du Front et du détroit de Davis émigrent vers les régions côtières de l'ouest et du sud du Groenland. Les stocks de la banquise de l'ouest n'ont jamais auparavant été associés à ceux du détroit de Davis ou du Front. On a cru que la population de phoques à capuchon déclinait en raison de l'exploitation massive dont elle fut l'objet à partir des années 1950 jusqu'aux années 1970; il est cependant impossible de le confirmer à cause de l'absence d'estimations adéquates de la population. Les relevés aériens et les vérifications au sol effectués récemment à l'égard des stocks du Front et du détroit de Davis révèlent que la population s'accroît. Au Canada, les phoques à capuchon ne sont pas menacés de disparition.

Key Words: Hooded Seals, *Cystophora cristata*, pinnipeds, sealing, Cystophorinae, bluebacks.

Hooded Seals, *Cystophora cristata*, (Figure 1) are large phocids, with no external pinnae. Adult pelage is grey to blue-back with an overlay pattern of irregular black spots. The face is black to behind the eyes (Reeves and Ling 1981). Adult males have an average length of 234 cm and average weight in excess of 300 kg (Mansfield 1967). They are characterized by their large elastic nasal cavity which is often inflated during agonistic encounters to form a rounded crest which looks like a black rubbery football, extending from the nostrils to the forehead. Relaxed, this inflatable bladder or “hood” appears wrinkled, overhanging the upper lip. Males can also extrude the red nasal septum through one of the nostrils to form a bubble-gum like balloon when the hood deflates. Females and immature males lack the inflatable hood and extrusible nasal septum. Sexual dimorphism is apparent at birth. Adult females have an average length of 203 cm and may be slightly shorter in the Jan Mayen herd. Female weights rarely exceed 300 kg (Mansfield 1967). The pup moults *in utero* and has a neonatal coat of slate or silver-blue-grey dorsally,

shading abruptly to silver grey on the sides and ventrum (Mansfield 1967).

Distribution

Hooded Seals are distributed along the coast of Greenland and into the Canadian eastern Arctic, south to the shores of Newfoundland and into the Gulf of St. Lawrence (Figure 2). Subadults have been reported in the western Beaufort Sea, but Hooded Seals are not common west of Baffin Bay and the Davis Strait (Mansfield 1967). Adults and young are commonly found in pack ice northeast of Greenland to about 77° N. They have been reported as far east as the Yenisey River (Ognev 1935) and regularly breed in small numbers in the Barents Sea and the Kara Sea (Ognev 1935; King 1964). Extralimital recoveries, especially of juveniles, have been recorded at Montreal on the St. Lawrence River, in Florida (Sergeant 1974) and on the coast of Europe to the Bay of Biscay (King 1964). Stray females have pupped successfully on the Maine coast as recently as 1974 (Richardson 1975).

Hooded Seal range and relative abundance may be considerably influenced by changes in ice cover and climate. Rasmussen (1960) has suggested that changes in the catch at Newfoundland and Jan Mayen are

*Not in jeopardy in Canada: NIAC (not in any COSEWIC category) April 1986.



FIGURE 1. Hooded Seal: adult female with "blueback" and head of adult male with proboscis erect (courtesy J. Lien, Memorial University of Newfoundland).

inter-related, showing that a reduction in abundance at Newfoundland coincides with an increased availability at Jan Mayen. He suggested this was related to availability of suitable ice for whelping and breeding. Vibe (1967) agreed with the conclusion that ice conditions influenced Hooded Seal distribution after examining historical catch data from south and west Greenland and the Davis Strait. Alternately, Kapel (1975) interpreted such changes as evidence of the effectiveness of management measures enforced in the Denmark Strait moulting aggregations.

Annual distribution is dependent on seasonal migratory patterns. There is a general southward migration with the onset of winter (Sergeant 1976a). The largest congregation of adults is thought to form for moulting in the Denmark Strait during summer between 66° and 68°N (Øritsland 1976) with others forming east of Greenland and 72° to 78°N (Sergeant 1974) and in northern Baffin Bay (Øritsland 1976). Peak abundance is from mid-June to mid-July. It is commonly held that the moulting patches may represent the total population (Rasmussen 1960; Øritsland 1976) although tagging studies fail to confirm this (Sergeant 1978; Jacobsen 1979).

On the completion of moulting, the population disperses, presumably to feed. Based on hunting records in Greenland (Kapel 1975, 1980, 1981, 1982, 1985), there is a gradual movement along the coast of

southeast Greenland, around Cape Farewell and up to northwest Greenland, north of Disko, at first involving juveniles and males, followed later by adult females.

Winter distribution is poorly known, but a general southerly migration for the Newfoundland stock is suggested by sightings on the Grand Banks off Newfoundland (Rasmusen 1960) and capture of juveniles off Labrador and northeastern Newfoundland in early winter (Sergeant 1976a).

Starting in February, gravid females and mature males concentrate near heavy ice in preparation for whelping and breeding in the latter half of March. Three such major areas have been identified: the "West Ice" near Jan Mayen, the Front off Newfoundland and Labrador and the Gulf of St. Lawrence, and a newly rediscovered area around 62°-64°N, 56°-60°W in the Davis Strait (Sergeant 1974; MacLaren Marex Inc. 1979). Small numbers also breed regularly in the Kara Sea and Barents Sea. The breeding distribution is not limited, but rather extensive (from the Gulf of St. Lawrence to the West Ice) and evidence (Rasmussen 1960) suggests that broad scale shifts in breeding areas have occurred in response to cyclic changes in marine climate.

After breeding, migration towards the moulting areas commences, coincident with heavy feeding *en route*. Large concentrations of Hooded Seals,

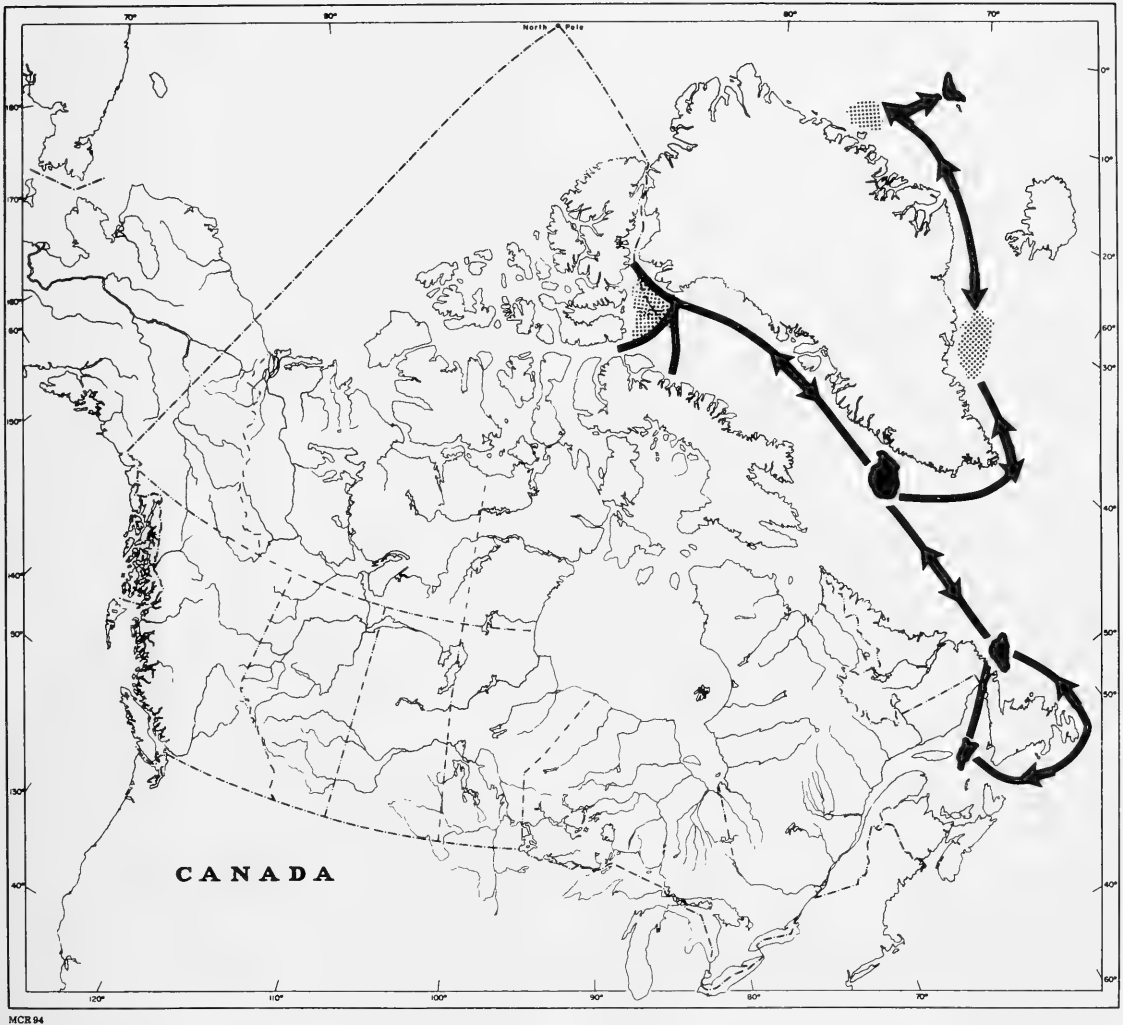


FIGURE 2. Hooded Seal (*Cystophora cristata*) distribution (from sources presented in the text). Breeding areas (dark patches). Mounting areas (stippled). Migration routes (arrows).

consisting first of juveniles and males, and later of mature females, appear off south Greenland around May and June (Kapel 1975, 1980, 1981).

Tagging studies (Sergeant 1978; Jacobsen 1979; Kapel 1982) link seals in Newfoundland with those in the Denmark Strait, but no tag returns link the West Ice population to those at Newfoundland, although the West Ice hoods are known to moult in the Denmark Strait too (Øritsland 1976). This may indicate that seals born in these two areas return to their respective birth regions to whelp and breed. Other studies concerning biochemistry (Naevdal

1971), anatomy and timing of whelping (Sergeant 1974) provide no insight into the degree of intermixing. Little is known of the nature and extent of interactions between the Davis Strait herd and those off Newfoundland and Jan Mayen. However, tagging studies conducted in 1984 indicate that seals from the Davis Strait may migrate to Greenland, and therefore, pups born in Davis Strait may contribute to Greenland catches (Anonymous 1985). A seal tagged off Newfoundland in late winter was recaptured along the Greenland coast in summer. Since the Davis Strait is on the migration path, it seems likely that the

Newfoundland and Davis Strait herds may also interact.

Protection

International

UNITED STATES: Hooded Seals do not usually enter U.S. waters. The U.S. is not engaged in commercial take of Hooded Seals. All marine mammals under U.S. jurisdiction are protected under the Marine Mammals Protection Act of 1972.

NORWAY AND USSR: Norway and the USSR are the only two countries still actively engaged in commercial sealing although Norwegian interests are only a fraction of those a decade ago. Norway, until 1982, participated in the hunt off the Front where catches were limited by mutual agreement with Canada as to regulations on quotas, take by sex, kill dates, and timings and humane slaughter methods.

Norwegian catches in the Denmark Strait were curtailed in 1960, and the Jan Mayen hunt has been regulated under a joint Norwegian/Soviet agreement since 1958. This hunt has been regulated by quotas, seasons, ship allocations, licensing of ship and restrictions on the take of females. Since 1982, the Norwegian participation in this hunt has been much reduced.

GREENLAND AND DENMARK: Denmark conducted commercial sealing through Greenland until 1967, when the last ship visited Denmark Strait and Jan Mayen. The Greenland hunt is now referred to as a subsistence hunt by the hunting communities of west and east Greenland and catches which averaged 1000 per year in the 1950s have now increased to over 5000 per year. This hunt is no longer carried out using traditional methods, as the seals are taken by rifle from motorboats and not by harpoons from kayaks. Pelts are sold through Denmark and the oil and meat marketing from the hunt is virtually unregulated.

TRADE BANS: In recent years, trade bans on Hooded Seal products have been initiated by several countries. The Marine Mammals Protection Act of 1972 bans importation of seal products in the USA, and New Zealand and Italy have enacted import bans on seal skins; the Netherlands have voluntarily boycotted the importation of seal skins since 1969; Sweden has done so since 1982. A two-year ban on the importation of whitecoat and blueback pelts was enacted in October 1983 by the Council of European Communities (EEC 1983) and extended for another four years in October 1985.

National

Under the terms of the Fisheries Act of Canada of 1867 (amended 1976, 1980) the Federal Department of Fisheries and Oceans is responsible for the management and regulation of marine mammals

including all seals in the Pacific, Atlantic and Arctic waters off Canada. Hooded Seals are regulated and managed under the Seal Protection Regulations of the Act.

Population Size and Trends

The relationships and degree of panmixia between Newfoundland, Davis Strait and Jan Mayen populations are not well understood. Rasmussen (1960) showed that fluctuations in catch and catch per unit effort of Hooded Seals for Newfoundland were greater than for Harp Seals, *Phoca groenlandica*, and could be attributed to movement of the seals in relation to changes in ice cover and climate. Furthermore, Rasmussen (1960) demonstrated that reduced availability in Newfoundland was related to increased availability at Jan Mayen. Sergeant (1974) suggested that the Newfoundland population could not be discrete or it would have been extirpated or severely depleted by the intensive exploitation from 1964 to 1973. Tagging studies have shown that seals tagged off Newfoundland, Davis Strait and in the Gulf of St. Lawrence have been recaptured off east and west Greenland (Sergeant 1974, 1978; Anonymous 1985). This suggests an integration of Hooded Seals at Denmark Strait, Davis Strait or Newfoundland during the breeding period. Seals tagged at Denmark Strait have been recaptured along the west Greenland and Newfoundland coasts (Hay et al. 1985a). However, no seals tagged at Jan Mayen have been recovered in the Denmark Strait, Davis Strait or Newfoundland (Øritsland as cited by Hay et al. 1985a). Bergflødt and Øritsland (1983) found no significant difference in the number of supernumerary teeth of Hooded Seals from Newfoundland or the Denmark Strait, but the pooled sample did differ from animals collected at Jan Mayen. These data are comparable to the tagging studies and suggest genetic isolation of West Ice and Northwest Atlantic stocks. Wiig and Lien (1984), however, found no morphological differences and concluded that there were few genetic differences in the two stocks.

Concern over the effect of hunting on population trends has been generated not only by the uncertainty of stock relationships, but also by the imprecision of abundance estimates (see Campbell 1985). Commercial hunting for Hooded Seals in Newfoundland goes back to the 19th century when they were hunted on the moulting grounds as early as 1874 (Reeves and Ling 1981). Commercial sealing has not occurred at whelping concentrations in the Davis Strait, although some animals may be taken in Inuit subsistence hunts and by Greenlanders along the west Greenland coast and in Denmark Strait. Commercial hunting in the Denmark Strait ended in 1960 following evidence of a population decline (Rasmussen 1960). Interestingly,

catch per unit effort subsequently increased in Newfoundland, suggesting an increase in population (Øritsland 1966, 1973) and supporting the Rasmussen (1960) hypothesis that the North Atlantic was represented by a single population of Hooded Seals. The stock would have separate breeding areas near Newfoundland and Jan Mayen and a common moulting area in the Denmark Strait.

Prior to 1974, little distinction was made between Hooded Seals and Harp Seals in the commercial hunts off Newfoundland and Greenland as there was little difference in their relative value. However, it is known that few Hooded Seals were taken at the Front. This is because of lower abundance relative to Harp Seals and the fact that the females are dispersed over a wider area (Sergeant 1976a). Following the development of a process which permitted the manufacture of furs from hair seal pelts (Sergeant 1976a), blueback pelts (young Hooded Seals 2–5 days old) became the most valuable of the various hair seal furs (McMillan *as cited by* the Nature Conservancy Council 1979) and hunting effort was increased on the species.

Harvest levels were generally unregulated until 1974 when the first Canadian quotas were introduced, although regulations were in place to enforce opening and closing dates, locations, catch equipment, etc. (*see* Campbell 1985). Norway had also undertaken some regulatory measures (*see* Campbell 1985). Although Denmark ceased commercial hunting of Hooded Seals in 1960, the Greenland hunt remained unregulated (although supposedly an aboriginal subsistence hunt). The 1974 Front quota of 15 000 was arbitrarily based on an assumed need for conservation (Anonymous 1972), and the assumption that the 1966 harvest of 16 000 pups was too high and that the quota should therefore be less.

Historically, assessments of the Hooded Seal populations (Tables 1 and 2) in the northwest Atlantic were restricted to the Front herd and sustainable yield calculations were not made until 1975. However, these and subsequent estimates depended on an estimate of average pup production for the 1960s. An estimate by the survival index model (Sergeant 1974; Øritsland and Benjaminsen 1975a; Winters and Bergflødt 1978) was then subject to ever increasing errors as the estimates had to be extrapolated to obtain current stock size estimates (Beddington and Williamson 1980; Doubleday and Bowen 1980; Roff and Bowen 1981; Anonymous 1983).

The only independent estimate of pup production was a survival estimate from the 1960s (Hay et al. 1985a) and this value depended on one data point. In only two years between 1974–1982 had the Hooded Seal quota been taken, and estimates indicated a

declining population (Tables 1 and 2). Faced with these factors, a comprehensive review of the Hooded Seal base was conducted by the International Council for Exploration of the Sea (ICES) Working Group on Harp and Hooded Seals in 1982. ICES (1983) concluded that the analyses of available data were not sufficient to produce reliable estimates of current population size, pup production or population abundance trends. Various sources of ancillary information, such as recent catch levels in Greenland and catch per unit effort on Norwegian vessels at the Front, provided evidence of increasing availability of Hooded Seals (ICES 1983). However, in view of the uncertainty brought to light in the review, total allowable catch (TAC) levels for 1983 were reduced to 12 000 animals at Canada's insistence.

In 1984, aerial surveys of both the Davis Strait and Front herds were successfully conducted (Anonymous 1985) and pup production at the Front in 1984 was estimated at 62 000 pups (95% confidence interval (C.I.) = 40 000 = 87 000) and for Davis Strait at 18 600 pups (95% C.I. = 13 800 = 23 400) (Anonymous 1985; Hay et al. 1985a). The results of these surveys were submitted to the Standing Committee on Fisheries Science (STACFIS) of the North Atlantic Fisheries Organization (NAFO) in Copenhagen, Denmark, in January 1985. STACFIS considered that the Davis Strait and Front estimate was biased downward due to the distinct possibility of whelping patches missed by the survey and because no correction had been applied for the Davis Strait for pups that had left the ice or were yet to be born (Anonymous 1985). Comparison of mortality rates of the two stocks (Davis Strait and Front) suggested that the two had been exposed to substantially different exploitation histories, at least in the last 10 years (Anonymous 1985; Hay et al. 1985a). Comparison of the 1984 estimate with that of the late 1960s indicated that the Hooded Seal population had probably increased in recent years whether the 1960 value of 30 000 represented the total Northwest Atlantic production or Front production alone (Anonymous 1985). Aerial surveys of the Front Herd in 1985 produced pup estimates of 61 400 (95% C.I. = 16 500 – 119 450). This estimate closely agreed with the 1984 estimate (Hay et al. 1985b).

Replacement yields for 1985 based on Front production alone ranged from 15 500 to 64 700 animals depending on the 95% C.I. and a range of M (Instantaneous Natural Mortality) from 0.07 to 0.13. Replacement yields were also calculated using three different hunting scenarios (a Greenland catch of 6000 animals and with catches at the Front of 0, 3000 and 12 000 seals) from which STACFIS concluded that pup production and populations would continue to

TABLE 1. Estimates of pup production for Hooded Seals from various sources.

Year	Area	Estimate	Confidence Intervals	Estimation Method	Reference
1960-1978	Front	—	24 000-30 000	SI ¹	Anonymous (1979)
Late 1960s	Front	40 000	—	SI	Anonymous (1981)
1966-1971	Front	27 000	—	SI	Sergeant (1976b)
1971-1978	Front	26 000	—	SPA ²	Winters and Bergflødt (1978)
1977	Front	25 000	—	SI	Sergeant (1977)
1977	Front	38 000	—	SPA	Anonymous (1978)
1979	Front	34 000	—	Unknown	Anonymous (1978)
1975	Davis Strait	13 000	—	Aerial census	MacLaren Marex Inc. (1979)
1977	Davis Strait	—	3-4000	Aerial census	Sergeant (1977)
1978	Davis Strait	11 000	—	Aerial census	Sergeant (1977)
1955	West Ice	120 000	—	Catch/ship	Øritsland (1976)
1970	West Ice	70 000	—	Catch/ship	Øritsland (1976)
1979	West Ice	50 000	—	SPA	Jacobsen (1979)
1984	Front	62 000	40 000-87 000	Aerial census	Hay et al. (1985a)
1984	Davis Strait	18 600	13 800-23 400	Ground Truthing	Hay et al. (1985a)
1985	Front	61 400	16 500-119 450	Aerial Census	Hay et al. (1985b)

¹Survival Index (Sergeant 1971).²Sequential Population Analysis (Ricker 1975).

increase over the next five years (Anonymous 1985).

There is less information available for the West Ice whelping aggregation. Øritsland (1976) used catch statistics and the relative strength of year classes in age analyses to arrive at an estimate of pup production at the West Ice of about 120 000 around 1955. The reduction in catches per ship suggested that availability of Hooded Seals was reduced by about

40% from 1955 to 1970, and it was assumed that pup production was correspondingly reduced (Ulltang and Øritsland 1971). Jacobsen (1979) attempted a sequential population analysis (SPA) estimate for this area using estimates of vital rates from the Front. The results of this analysis suggest that pup production was approximately 50 000 pups in 1975. No current figures for the West Ice are available.

TABLE 2. Estimates of total population (1+) for Hooded Seals from various sources.

Year	Area	Estimate	Confidence Intervals	Estimation Method	Reference
1960-1978	Front	—	48 000-55 000 ³	SPA	Anonymous (1979)
Late 1960s	Front	53 000 ¹	—	Unknown	Anonymous (1978)
1962-1978	Front	100 000	—	SI/SPA	Winters and Bergflødt (1978)
1977	Front	77 000 ¹	—	Unknown	Anonymous (1978)
1975	Davis Strait	42 000 ²	—	Aerial census	MacLaren Marex Inc. (1979)
1978	Davis Strait	34 000 ²	—	Aerial census	MacLaren Marex Inc. (1979)
1959	Total	230 000 ³	—	Aerial census	Øritsland (1959)
1960	Total	505 000 ³	—	Unknown	Øritsland (1960)
1960	Total	500 000 ³	—	Unknown	Rasmussen (1960)
		248 000 ²	—	Aerial census	Hay et al. (1985a)
1984	Front	(310 000) ⁴			
	Davis Strait	74 440 ²		Aerial census	Hay et al. (1985a), Winters (personal communication)
		(93 000) ⁴			
1985	Front	256 600 ²		Aerial census	Hay et al. (1985b), Stenson (personal communication)
		(307 000) ⁴			

¹Adult females only.²Extrapolated from pup census.³Assumed total population moulted in Denmark Strait.⁴Total population (general rule of thumb is total population = pups production x5; 1+ population = pup population x4).

As all estimates of adult abundance are derived from estimates of pup production, they are subject to the same uncertainty. Winters and Bergflødt (1978) suggest the Front stock of Hooded Seals was stable at approximately 100 000 adult females between 1962 and 1978. Estimates of stock size for the Davis Strait population range between 34 000 and 42 000 for 1978 and 1975, respectively (MacLaren Marex Inc. 1979). Winters (personal communication) estimated the stock size of the Davis Strait population at 93 000 animals (Table 2), and the Front population at 310 000 based on the 1984 surveys (Hay et al. 1985a). Based on the 1985 survey (Hay et al. 1985b), Stenson (personal communication) estimated 307 000 animals in the 1985 Front population. There are no current estimates of adult or pup abundance for the West Ice stock, and without a knowledge of the degree of mixing between these stocks, it is not possible to put such estimates in the context of the total population.

Habitat

The habitat of the Hooded Seal includes considerable portions of the Northwest Atlantic and the Arctic Ocean along both the east and west coasts of Greenland (Figure 2).

They are known to inhabit the edge of the heavy pack ice for breeding and moulting and have been found in association with the ice edge at other times of the year (Stewart, personal communication; MacLaren Marex Inc. 1979). Hooded Seal distribution is thus considered to be influenced by climatic factors, to the extent that the latter determine the presence and distribution of pack ice (Rasmussen 1960; Vibe 1967; Sergeant 1974, 1976a).

Little of the area frequented by Hooded Seals has been strongly influenced by human activity; human population is sparse and ocean currents tend to flow towards populated areas rather than carry effluent into these waters. Major industrial activities are limited to oil and gas exploration and such activity is closely regulated by both federal and provincial levels of Canadian government. High levels of mercury have been recovered in a small sample of Hooded Seals from Davis Strait (Sergeant and Armstrong 1973) although more recent studies of other pinnipeds (Ringed Seals, *Phoca hispida*, and Bearded Seals, *Erignathus barbatus*) from a similar area have shown that the mercury is present in a harmless, inorganic form (Smith and Armstrong 1978). There is some question as to whether the mercury is of industrial origin or naturally occurring (K. Ronald, J. Dougan, R. Frank and H. E. Brown, unpublished research report on biocides, University of Guelph).

General Biology

Whelping occurs on thick pack ice in late March to early April. The nursing period is short and intensive, perhaps eight days or less, after which the pup can quickly move into the water (Bowen, personal communication; Mansfield 1967).

The sex ratio at birth is very close to 1:1 (Øritsland 1964; Øritsland and Benjaminsen 1975 a,b). Since females are more likely to defend their pups vigorously, they have, before the introduction of specific regulations protecting them, constituted the larger proportion of the adult catch (Øritsland and Benjaminsen 1975 a,b). This may account for the slight preponderance of males noted by Øritsland (1964) in moulting patches in Denmark Strait.

Breeding behaviour of the adults commences at weaning, with dominant males defending the right to mate with females with agonistic displays and aggressive actions towards competitors. The "family group" commonly described consists of the mother and her nursing pup and a male protecting the female from other male attention (Stewart, personal communication; Sergeant 1976). At present it is not known whether the Hooded Seal is polygamous or monogamous although indirect evidence tends to suggest that males are opportunistically polygamous (Stewart, personal communication).

After breeding season is completed, adults migrate northward following the pack ice, feeding as they go. Sergeant (1976) argues that Hooded Seals tend to use deep water for their feeding, taking fish such as redfish (*Sebastes* sp.) and Greenland Halibut (*Reinhardtius hippoglossoides*) at depths of up to 200 m. Pelagic fish such as Capelin (*Mallotus villosus*) and Polar Cod (*Boreogadus saida*), and crustacea and mollusca such as Squid (*Gonatus fabricii*), are also food items. Little is known of the variation in diet throughout the year, by age or sex classes. They do not appear to feed during breeding or moulting.

Based on analysis of catches from Greenland, it seems that females may lag behind the males and juveniles in their migration towards the moulting areas (Kapel 1981). Moulting concentrations begin to form in June and a few animals remain to the end of July (Rasmussen 1960).

Upon completion of moulting the seals disperse to feed. Little is known of their life history during the period of the year between moulting and congregation for whelping and breeding in the spring although they are thought to be solitary (Stewart, personal communication).

Vital Rates

Delayed implantation of the blastocyst occurs in the Hooded Seal, possibly as late as late July or early

August (Øritsland 1964, Börn 1980), after the seals have dispersed following their aggregation phases to whelp and breed (late March – early April) and to moult (June to August). Sampling of females for the determination of fertility rates and reproductive success has been carried out during the aggregation phases, but not in significant numbers during the dispersal phase after implantation has occurred. Thus it has not been possible to directly estimate fertility rates and reproductive success through actual observation of foetuses, since implantation and the start of foetal development occur only after August.

Age at sexual maturity in female Hooded Seals was studied in detail by Øritsland (1964, 1975). He sampled mature and immature females collected partly at the West Ice (Jan Mayen area) during the breeding season and partly in the Denmark Strait in moulting aggregations. He assumed that corpora albicantia present in the ovaries persist for at least two years. By counting the number of corpora albicantia present and back-calculating against the age of the animal as determined by tooth sectioning, the age at which first ovulation occurred was determined for females which had matured within the last two years before capture. Sexual maturity as indicated by age at first ovulation in his sample was determined to have occurred at ages of from two (7.1%) to eight (1.2%) years. More than 50% matured at age three years and gave birth to the first pup at four years.

Based on the assumption that corpora lutea of pregnancy or corpora albicantia of lactation are criteria of pregnancy, study of the ovaries has revealed that about 95% of the sexually mature females became pregnant every year. Fecundity in mature females was found to increase to a maximum (approaching 100%) in the five year age class, declining to 98% at age eight when all females are mature (Øritsland 1964, 1975).

In a study based on ovaries and teeth collected from lactating females obtained at the Front off Newfoundland-Labrador, Øritsland (1964, 1971, 1975) calculated the distribution of age at maturity of all 3–13 year old females in his sample which had attained sexual maturity within the three preceding breeding seasons. Breaks in the regular size sequence of corpora alternating between the two ovaries over the three years preceding capture were taken to indicate missed pregnancies. The results of this study indicated that sexual maturity was attained at ages ranging from two years (12%) to nine years (2%), with 50% of the females reaching maturity at 2.8 years. The incidence of missed pregnancies were higher in young than in older animals: the pregnancy rate amongst 3–10 year old mature females was calculated

to be 0.969, while that for 11–34 year old females was 0.988 with an overall rate for the 3–34 year old sample of 0.973. Øritsland suggested a rate of 0.95 as a conservative estimate of average reproductive success of mature female Hooded Seals in the Northwest Atlantic.

Börn (1980) examined reproductive tracts from both mature and immature female Hooded Seals caught from April to late July in 1970–71 in south and southeast Greenland. From the distribution of age at first ovulation in that portion of his sample which had first ovulated within three years prior to capture, he found that sexual maturity is attained from two years (19.6%) to nine years (4.3%) of age, with 3.2 years as the median age of sexual maturity. Reproductive success or pregnancy rate was calculated according to three different methods: 1) the determination of the ratio of the animals with a corpus luteum to all mature animals in the sample; 2) the determination of the ratio of the number of mature animals with large normal-looking corpus albicans associated with a uterine horn displaying post-partum changes to that of animals with corpora albicantia associated with immature uterine horns; 3) Øritsland's (1971 and 1975) technique based upon the determination of "missing" corpora within the last three breeding cycles. These yielded an average estimate of production of 0.936 young per year for mature females 3 to 22 years of age. None of the three estimates of reproductive success differed significantly and Börn concluded that the pregnancy rate of 0.95 suggested by Øritsland is realistic for management purposes. Although Börn's study did indicate that varying regression rates of corpora albicantia may influence the significance of a break in their normal size sequence, he concluded that average reproductive success may well be estimated from the sequence of corpora albicantia.

Catch curve analysis of populations is a common method of determining mortality rates (Ricker 1975). However, the most common mode of analysis, that of fitting a regression to the right, downward sloping segment of the curve, may be biased (Chapman and Robson 1960). They recommend use of ratios between sequential age classes to arrive at an unbiased estimate of total instantaneous mortality (Z).

Separation of total mortality into its components; those caused by hunting (F), and those resulting from all other causes (M), requires a knowledge of the nature of the hunting effort and its effect on mortality rate of the populations (Ricker 1975). Note that M is normally defined as the instantaneous rate of natural mortality. In the case of seals, hunting effort is not well related to hunting mortality, so estimates of F

TABLE 3. Summary of estimates of Instantaneous Total Mortality (Z) and Instantaneous Natural Mortality (M) for Hooded Seals. Values are from various sources using the stated methods.

Year	Area	Z	Confidence Limits	M	Confidence Limits	Method	Reference
1960-1977	Front	—	—	0.12 ¹	—	Catch Curve	Anonymous (1978)
1964-1972	Front	—	—	0.13	—	Catch Curve	Winters and Bergflødt (1978)
1971-1976	Front	0.27	0.19-0.35	0.14	0.06-0.22	Catch Curve	Winters and Bergflødt (1978)
1975	West Ice	0.22	—	—	0.09-0.15	Mean age	Flipse and Veling (1981)
1975	West Ice	—	—	0.12	—	SPA ²	Jacobsen (1979, 1984)
1979	Front	—	0.22-0.24 ¹	—	0.11-0.13 ¹	Various	Anonymous (1981)
1984	Davis Strait	0.14	0.12-0.17	—	—	Catch Curve	Anonymous (1985)

¹Adult females only.²Sequential Population Analysis (Ricker 1975).

are difficult, if possible at all. All of the estimates reported here (Table 3) are based on assumptions or techniques open to criticism for one reason or another (Anonymous 1979; Beddington and Williams 1980; Roff and Bowen 1981; Ugland 1982). Theoretically, any value for M between 0.05 and 0.15 is feasible for a marine mammal the size of a Hooded Seal (Roff and Bowen 1980) and none of the reported estimates is impossible. Using the method of Chapman and Robson (1960) the total mortality rate was calculated for the Davis Strait population at Z (Instantaneous Total Mortality) = 0.142 (95% C.I. = 0.115 - 0.166) with M taken at 0.07 = 0.13 as accepted previously (Anonymous 1983).

This aspect of Hooded Seal biology requires further research. The estimation of natural mortality is difficult for any natural population and no less difficult for pinnipeds.

Limiting Factors

The migratory routes and whelping areas of Hooded Seals occur in areas of potential oil and gas are exploration (CARC 1979) and/or transportation corridors for northern shipping (CARC 1982). The effects of the day-to-day operation of fuel carriers or the impact of oil spill or "blowouts" on these animals is not fully understood, and no acceptable technology is yet available to deal with such matters (Pimlott et al. 1976; CARC 1981; Pederson 1981). At present, these concerns are not limiting to the population.

Since much of the distribution of these seals is in an area important to the commercial fishery, depletion of food supply (eg. over-fishing) has often been broached as a limiting factor (Anonymous 1984). Certain prey species such as redfish and Capelin appear to show cyclic periods of abundance which may not be related to over-fishing (Kulka, personal communication), but

these species have recently been shown to be increasing in abundance (Misra and Carscadden 1983; Miller and Carscadden 1983; DFO 1985). The question of the relationship of commercial fisheries and the food supply is not resolved.

The extent of commercial exploitation of the species is doubtless a limiting factor to Hooded Seal abundance. Hooded Seals in the northwest Atlantic have endured continuous, and at times heavy, exploitation for over 150 years. The pelts of the young (known as bluebacks) were an important aspect of the fur seal trade and may have accounted for up to 30% of their catch and half the total value of trade in hair seal pelts (Sergeant 1976b). The adults were utilized in the production of seal oil and to some extent leather, but Hooded Seals have been relatively less important than Harp Seals to Canadian sealers, the catch rarely attaining 10% of the latter. Fewer Hooded Seals are taken at the Front because of their lower abundance relative to Harp Seals and the fact that females are dispersed over a wider area (Sergeant 1976a).

Historically, assessments of Hooded Seal abundance in the northwest Atlantic have been related to the Front (Tables 1 and 2) although two more recent assessments have been conducted for the Jan Mayen stock (Jacobsen 1979; Flipse and Veling 1981). Sustainable yield calculations were not made until 1975. However, these and subsequent estimates depended on an estimate of average pup production for the 1960s as estimated by a survival index method (Øritsland and Benjaminsen 1975a; Sergeant 1975; Winters and Bergflødt 1978) and were then subject to increasing bias as the estimate had to be extrapolated to obtain current stock size estimates (Beddington and Williams 1980; Doubleday and Bowen 1980; Roff and Bowen 1981; Ugland 1982; Anonymous 1983). Since catch quotas were not being met there was a feeling in

some circles that this was evidence of a declining population. ICES (1983) reviewed the situation and concluded that there was some uncertainty as to population status and sustainable yields and provided the recommendation for the Canadian and Canadian-Danish investigation initiatives in 1984, which have produced evidence of increases in the Davis Strait and Front stocks (Anonymous 1985; Hay et al. 1985a,b).

Scheffer (1958) estimated a world population of 300 000–500 000 animals and Popov (1976) suggested a population size of 500 000–600 000. The Front herd was estimated to be stable at 100 000 animals from 1963 to 1979. Jacobsen (1979) and Øritsland (1976) estimated the population size for Jan Mayen at 200 000 in 1970, a decline from an earlier estimate of up to 500 000 in 1955. Current estimates of the Front and Davis Strait populations are in the order of 90 000 and 300 000 animals, respectively (Table 2).

There is no clear evidence to show that harvesting of the Front herd (*see* Campbell 1985 for review of catch and trade statistics) had produced a decline in Hooded Seals in the Northwest Atlantic, although there may be some evidence of this (as described above) for the Jan Mayen populations. Clearly, unregulated hunting would limit populations. However, given the current market situation and the response of the sealing industry, exploitation is not a limiting factor at present.

Special Significance of the Species

In the past, Hooded Seals have been an important source of income and food for Canadian sealers, including the Inuit. The flippers and meat are utilized for food not only in Canada but in other countries as well. The Inuit of Canada and Greenland rely heavily on seals for their subsistence although Hooded Seals are not a major species for the Canadian Inuit. The utilization of Hooded Seals by the Greenland Inuit appears to be more of a commercial nature than one of subsistence.

Although blueback pelts accounted for 30% of the hair seal fur trade (Sergeant 1976b) they accounted for only 10% of the seal catch on the Front. This hunt was composed mostly of Harp Seals (Sergeant 1976a), which tend to be more abundant and aggregated for whelping.

From 1970 to 1978, the value of Hooded Seal skins fluctuated considerably in real value, dropping to a low point in 1974 (Barzdo 1980) corresponding to a bottoming-out in value of short-hair seal skins of other species which seriously affected Canadian Inuit communities in 1976 and 1977. This may have been due in large part to anti-sealing campaigns although fashion may have also had a role. Increasing demand

from 1978 to 1981 was reflected in increasing value of Hooded Seal pelts, especially bluebacks, which command the highest price of all hair seal skins.

The intensification of anti-sealing campaigns directed specifically at Harp Seal whitecoat and Hooded Seal blueback pups, especially in Europe, has resulted in a ban on the importation of whitecoat and blueback pelts into the European Economic Community until 1989. This ban paralyzed the market for all seal pelts and dramatically lowered prices.

Hooded Seal skins can readily be differentiated from those of other species. The seals themselves are easily identifiable and cannot be confused with other hair or fur seals.

Evaluation

Hooded Seals appear to be well managed and regulated in Canada and evidence indicates that populations are at or above historic levels and increasing. Should current market conditions be reversed, commercial hunting based on adequate estimates of sustainable yield should not unduly affect these populations. The Hooded Seal is not in jeopardy in Canada.

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Literature Cited

- Anonymous.** 1972. Proceedings of the 22nd Annual Meeting of the International Commission for the Northwest Atlantic Fisheries, Proceedings Number 8.
- Anonymous.** 1978. Report of the Ad Hoc Working Group on Seals. International Commission for the Northwest Atlantic Fisheries Redbook 1978: 17–20.
- Anonymous.** 1979. Report of Standing Committee on Research and Statistics (STACRES). Special Meeting on Seals and Shrimp, November 1978. International Commission for the Northwest Atlantic Fisheries Red Book 1979: 5–26.
- Anonymous.** 1981. Special Meeting of Scientific Council — November 1981. Northwest Atlantic Fisheries Organization Scientific Council Summary Document 81/XI/29.
- Anonymous.** 1983. Scientific Council Report 1983. Northwest Atlantic Fisheries Organization Scientific Council Summary Document 83/I/1.

- Anonymous.** 1984. Hooded Seal (*Cystophora cristata*) a proposal to list the hooded seal on CITES Appendix II of the Convention on International Trade in Endangered Species (CITES). CITES Authority, Stockholm, Sweden.
- Anonymous.** 1985. Report of Standing Committee on Fisheries Science (STACFIS). Scientific Council Meeting of the Northwest Atlantic Fisheries Organization January 1985, Northwest Atlantic Fisheries Organization Scientific Council Summary Document 85/1/1.
- Barzdo, J.** 1980. International trade in harp and hooded seals. Fauna and Flora Preservation Society, London.
- Beddington, J. R., and H. A. Williams.** 1980. The status and management of the harp seal in the Northwest Atlantic: a review and evaluation. U.S. Marine Mammal Commission, National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia. Report Number MMC/79/03.
- Bergflødt, B., and T. Øritsland.** 1983. Frequencies of super-numerary teeth in the lower jaws of North Atlantic Hooded and Harp seals. Hooded Seal Workshop, Bergen, Norway 1983. Document HWS-83/13.
- Börn, E. W.** 1980. Age of sexual maturity and reproductive performance of the female Hooded Seal (*Cystophora cristata* Erxleben) in South Greenland. Northwest Atlantic Fisheries Organization Scientific Council Report Document 80/XI/158.
- Campbell, R. R.** 1985. Status of the Hooded Seal in Canada, CITES Status Report, Department of Fisheries and Oceans, Ottawa.
- CARC.** 1978. Northern perspectives. Canadian Arctic Resources Committee, Ottawa 6(6).
- CARC.** 1979. Northern perspectives. Canadian Arctic Resources Committee, Ottawa 7(6).
- CARC.** 1981. Northern perspectives. Canadian Arctic Resources Committee, Ottawa 9(4/5).
- CARC.** 1982. Northern perspectives. Canadian Arctic Resources Committee, Ottawa 10(3).
- Chapman, D. G., and D. S. Robson.** 1960. The analysis of a catch curve. Biometrics 16: 354-368.
- DFO.** 1985. Department of Fisheries and Oceans Canada — Resource Prospects for Atlantic Fisheries 1986-1990. Department of Fisheries and Oceans, Ottawa.
- Doubleday, W. G., and W. D. Bowen.** 1980. Inconsistencies in reading the age of Harp Seal (*Pagophilus groenlandicus*) teeth, their consequences and a means of reducing the resulting biases. Northwest Atlantic Fisheries Organization Scientific Council Report Document 80/XI/160.
- EEC.** 1983. Council of the European Communities. Council Directive 83/29/EEC. Journal of the European Economic Communities Number L91/30.
- Flipse, E., and E. J. M. Veling.** 1981. An application of the Leslie matrix model to the population dynamics of the Hooded Seal (*Cystophora cristata* Erxleben). Manuscript Stichting Mathematisch Centrum. Paper Antwerp TN101/81.
- Hay, K., A. Myers, and W. D. Bowen.** 1985a. Estimation of pup production of Hooded Seals (*Cystophora cristata*) in the Northwest Atlantic during March 1984. Northwest Atlantic Fisheries Organization Scientific Council Report Document 85/1/14.
- Hay, K., C. B. Steson, D. Wakeham, and R. A. Meyers.** 1985b. Estimation of pup production of Hooded Seals (*Cystophora cristata*) at Newfoundland during March 1985. Canadian Atlantic Fisheries Scientific Advisory Committee Research Document 85/96.
- ICES.** 1983. Report on the meeting of the *Ad Hoc* Working Group on assessment of Harp and Hooded seals in the Northwest Atlantic. International Council for the Exploration of the Sea. Environmental Research Report Number 1211.
- Jacobsen, N. O.** 1979. [Pup production, age at first pupping and natural mortality of Hooded Seals in the West Ice] Produksjon, alder ved første gangs kasting og naturlig dodelighet hos klappmyss, *Cystophora cristata* (Erxleben, 1777) I. vesterisen. Manuscript Institutt for fiskeribiologi, Universitetet i Bergen, *Veren* 1979.
- Jacobsen, N. O.** 1984. Estimates of pup production, age at first parturition and natural mortality for hooded seals in the West Ice. Fiskeridirektoratets Skrifter Serie HavUndersokelser 17: 483-498.
- Kapel, F. O.** 1975. Recent research on seals and seal hunting in Greenland. Rapports et Procès-Verbaux des Réunions de la Commission Internationale pour l'Exploration de la Mer 169: 462-478.
- Kapel, F. O.** 1980. Review of studies of Hooded Seal in Greenland, 1970-1979. Northwest Atlantic Fisheries Organization Scientific Council Report Document 80/XI/170.
- Kapel, F. O.** 1981. Studies of Hooded Seal in Greenland, 1970-1980. Northwest Atlantic Fisheries Organization Scientific Council Report Document 81/XI/150.
- Kapel, F. O.** 1982. Studies on the Hooded seal, *Cystophora cristata*, in Greenland, 1970-1980. Northwest Atlantic Fisheries Organization Scientific Council Studies 3: 67-65.
- Kapel, F. O.** 1985. Trends in catches of Harp and Hooded seals in Greenland, 1939-83. Northwest Atlantic Fisheries Organization Scientific Council Report 85/1/9.
- King, J.** 1964. Seals of the world. British Museum of Natural History, London.
- MacLaren Marex Inc.** 1979. Report on aerial surveys of marine mammals and birds in southern Davis Strait and eastern Hudson Strait in March, 1978 for Esso Resources Canada Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd., Arctic Petroleum Operators Association, Calgary, Alberta.
- Mansfield, A. W.** 1967. Seals of Arctic and eastern Canada. Fisheries Research Board of Canada Publication, Ottawa.
- Mercer, M. C.** 1979. Management of Northwest Atlantic Harp Seals. International Workshop on Biology and Management of Northwest Atlantic Harp Seals (Sponsored by the International Union of the Conservation of Nature and the World Wildlife Fund) University of Guelph, 3-6 December 1979. Working Paper HFWP Number 8 [revised]: 710-717.
- Miller, D. S., and J. E. Carscadden.** 1983. Capelin acoustic Surveys NAFO Divisions 2J + 3K and 3LNO. 1982. Northwest Atlantic Fisheries Organization Scientific Council Report Document 83/VI/50.

- Misra, R. K., and J. E. Carscadden.** 1983. Stock discrimination of capelin (*Mallotus villosus*) in the Northwest Atlantic using meristic characters. Northwest Atlantic Fisheries Organization Scientific Council Report Document 83/VI/49.
- Naevdal, G.** 1971. Serological studies on Marine Mammals. Rapports et Procès-Verbaux des Réunions de la Commission Internationale pour l'Exploration de la Mer 161: 136-138.
- Nature Conservancy Council of Great Britain.** 1979. Preliminary status report on the marine mammals of major relevance to Europe. Prepared for Environment and Consumer Protection Service of the Commission of the European Communities. Nature Conservancy Council, London.
- Ognev, S. I.** 1935. Mammals of the USSR and adjacent countries. Vol. III: Carnivora (Fissipedia and Pinnipedia). Isreal Program for Scientific Translations. Jerusalem, 1962.
- Øritsland, T.** 1959. Klappmyss (Hooded Seal). Fauna, Oslo, 12: 70-90.
- Øritsland, T.** 1960. Flyetling etter Klappmyss på langstfelte i Danmark stredet. Fauna, Oslo, 13: 153-162.
- Øritsland, T.** 1964. Klappmysshunnens Forplantingsbiologi. (The breeding biology of female Hooded Seals). Fiskets Gang 50: 5-19.
- Øritsland, T.** 1966. Norwegian catch and effort statistics for Harp and Hooded seals in the Front area and the Gulf area, 1937-1966. International Commission for the Northwest Atlantic Fisheries Contribution Number 8 to Panel A, Serial Number 1760.
- Øritsland, T.** 1971. The status of Norwegian studies of Harp Seals at Newfoundland. International Commission for the Northwest Atlantic Fisheries Red Book III: 157-183.
- Øritsland, T.** 1972. Norwegian catches of Hooded Seals (*Cystophora cristata*) in the Denmark Strait. 1945-1960. Report of the Institute for Marine Research, Bergen, 22 February 1972: 1.
- Øritsland, T.** 1975. Sexual maturity and reproductive performance of female Hooded Seals at Newfoundland. International Commission for the Northwest Atlantic Fisheries Research Bulletin 11: 37-41.
- Øritsland, T.** 1976. The management of Harp and Hooded Seals in the West Ice. International Council for the Exploration of the Sea Council Minutes 1976/N-17.
- Øritsland, T., and T. Benjaminsen.** 1975a. Additional data on the sex ratio, age composition and mortality of Newfoundland hooded seals, with an estimate of pup production and sustainable yield. International Commission for the Northwest Atlantic Fisheries Research Document 75/122.
- Øritsland, T., and T. Benjaminsen.** 1975b. Sex ratio, age, composition and mortality of hooded seals at Newfoundland. International Commission for the Northwest Atlantic Fisheries Research Bulletin 11: 135-143.
- Popov, L. A.** 1976. Status of main ice forms of seals inhabiting waters of the USSR and adjacent to the country marine areas. Food and Agriculture Organization of the United Nations Advisory Council on Marine Renewable Resources ACMRR/MM/SC/51.
- Pederson, N. M. Editor.** 1981. The question of sound from icebreaker operations: Proceedings of the Arctic Pilot Project Workshop Sponsored by Petro-Canada, Calgary, 23-24 February 1981. Department of Indian Affairs and Northern Development, Ottawa.
- Pimlott, D. H., D. Brown, and K. P. Sami.** 1976. Oil under the ice. Canadian Arctic Resources Committee, Ottawa.
- Pinhorn, A. T. Editor.** 1976. Living marine resources of Newfoundland and Labrador: status and potential. Fisheries Research Board of Canada Bulletin 194.
- Rasmussen, B.** 1960. Om klappmyssbestanden i det nordlige Atlanterhav [On the stock of hooded seals in the North Atlantic]. Fish og Havet 1: [Fisheries Research Board of Canada Translation Series Number 387].
- Reeves, R. R., and J. K. Ling.** 1981. Hooded seal, *Cystophora cristata* Erxleben, 1777. Pages 171-194 in Handbook of marine mammals Volume 2 — seals. Edited by S. H. Ridgeway and R. J. Harrison. Academic Press, London.
- Richardson, D. T.** 1975. Hooded seal whelps at South Brookville, Maine. Journal of Mammalogy 56: 698-699.
- Ricker, W. E.** 1975. Mortality and production of harp seals with reference to a paper by Benjaminsen and Øritsland (1975). International Commission for the Northwest Atlantic Fisheries Research Document 75/XII/143.
- Roff, D. A., and W. D. Bowen.** 1981. Population dynamics of harp seals, 1967-1991. Northwest Atlantic Fisheries Organization Scientific Council Report Document 81/XI/166.
- Scheffer, V. B.** 1958. Seals, sea lions and walruses: a review of the pinnipeds. Stanford University Press, San Francisco.
- Sergeant, D. E.** 1971. Calculation of production of harp seals in the western North Atlantic. International Commission for the Northwest Atlantic Fisheries Redbook 1971, Part 3: 157-184.
- Sergeant, D. E.** 1974. A rediscovered whelping population of Hooded Seals, *Cystophora cristata* Erxleben and its possible relationship to other populations. Polarforschung 44(1): 1-7.
- Sergeant, D. E.** 1975. Comments on new estimates of production and sustainable yield of harp and hooded seals. International Commission for the Northwest Atlantic Fisheries Research Document 75/147.
- Sergeant, D. E.** 1976a. History and present status of populations of Harp and Hooded Seals. Biological Conservation 10: 95-118.
- Sergeant, D. E.** 1976b. Research on Hood Seals *Cystophora cristata* Erxleben in 1976. International Commission for the Northwest Atlantic Fisheries Research Document 76/X/126 [revised].
- Sergeant, D. E.** 1977. Research on Hood Seals in the western North Atlantic in 1977. International Commission for the Northwest Atlantic Fisheries Research Document 77/XI/57.
- Sergeant, D. E.** 1978. Results of tagging and branding of Hooded Seals, 1972-1978. International Commission for the Northwest Atlantic Fisheries Research Document 78/XI/86.
- Sergeant, D. E., and F. A. J. Armstrong.** 1973. Mercury in seals from eastern Canada. Journal of the Fisheries Research Board of Canada 20: 843-846.

- Smith, T. G., and F. A. J. Armstrong.** 1978. Mercury and selenium in Ringed and Bearded Seal tissue from Arctic Canada. *Arctic* 31: 76-84.
- Ugland, K. I.** 1982. Abundance estimation of the North Western Atlantic Harp Seal population. Northwest Atlantic Fisheries Organization Scientific Council Working Paper 82/24.
- Ulltang, O., and T. Øritsland.** 1971. [Stock size and exploitation of harp and hooded seals in the West Ice] Bestand og beskatning av grønlandsel og klapmyss i Vesterisen. Notat Fiskeridirektoratets Hav Forskning Institutt Norges 1971: 1-7.
- Vibe, C.** 1967. Arctic animals in relation to climatic fluctuations. *Meddeleser om Grønland* 170(5): 1-277.
- Wiig, O., and R. W. Lie.** 1984. An analysis of the morphological relationships between the hooded seals (*Cystophora cristata*) of Newfoundland, the Denmark Strait and Jan Mayen. *Journal of Zoology* 203: 227-240.
- Winters, G. H., and B. Bergflødt.** 1978. Mortality and productivity of the Newfoundland Hooded Seal stock. International Commission for the Northwest Atlantic Fisheries Research Document 78/X1/91.

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Status of the Northern Elephant Seal, *Mirounga angustirostris*, in Canada*

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The Northern Elephant Seal, *Mirounga angustirostris*, inhabits the Pacific coast of North America, with breeding colonies occurring historically from the Point Reyes Peninsula, north of San Francisco to Cabo San Lazaro and Magdalena Bay, Baja California, Mexico. Feeding areas ranged from the tip of the Baja Peninsula to British Columbia and southeast Alaska. These seals were virtually exterminated through commercial sealing by 1860. Elephant Seals under the protection of Mexican law and later U.S. regulation have made a remarkable recovery and now reoccupy almost all of their historic breeding range, and are so common as to be no longer considered rare or endangered.

L'éléphant de mer du nord, *Mirounga angustirostris*, fréquente les eaux côtières de l'océan Pacifique nord-américain. Historiquement, on trouvait des colonies de reproducteurs de la péninsule Point Reyes au nord de San Francisco jusqu'à Cabo San Lazaro et la baie Magdalena, en Basse Californie (Mexique). Les aires d'alimentation s'étendaient de l'extrémité de la péninsule Baja à la Colombie-Britannique et jusqu'au sud-est de l'Alaska. Dès 1860, la chasse commerciale de ces animaux les avait quasiment exterminés. Protégé par la loi mexicaine et plus tard par un règlement américain, l'éléphant de mer n'a cessé de proliférer et il réoccupe maintenant presque toute son ancienne aire de répartition de reproducteurs; il est devenu tellement commun qu'il n'est plus considéré comme rare ou menacé de disparition.

Key Words: Northern Elephant Seal, *Mirounga angustirostris*, Cystophorinae, sealing, pinnipeds.

Northern Elephant Seals, *Mirounga angustirostris* (Figure 1) are the largest pinnipeds in the northern hemisphere and of all pinnipeds are second in size only to *Mirounga leonina*, the Southern Elephant Seal. Adult females (cows) weigh up to 900 kg and are about 3 m in length. The adult males (bulls) may reach a weight of 2700 kg and up to 6 m in total length. Another feature of the species is the greatly enlarged and elongated nasal chamber (proboscis) of the males which gives them an elephantine appearance. The coat of both sexes is light brown and the hair and epidermis undergo an annual moult. The males develop a pink and grey mottled layer of cornified skin on the chest and neck (ventrally) at maturity (see McGinnis and Schusterman 1981 for descriptive details).

Distribution

Northern Elephant Seals historically occupied the Pacific coast of North America. They bred from the Point Reyes Peninsula north of San Francisco south to Cabo San Lazaro and Magdalena Bay, Baja California, Mexico (Scammon 1874). Feeding areas for some population segments ranged from the tip of Baja California north to British Columbia and

sometimes southeast Alaska. Commercial sealing in the 19th century almost exterminated the species and extirpated rookeries on all but Isla de Guadalupe.

Northern Elephant Seals have reoccupied almost all their historic breeding range and breed from Isla Natividad, Baja California, north to the Farallon Island(s) off San Francisco (Figure 2). Bulls sometimes reach southeast Alaska. Ten rookeries are known, and three more may be developing (Bonnell et al. 1980; Antonelis et al. 1981). Two of these 13 sites involve pupping on the mainland. Non-breeding individuals (yearlings and bulls) have been sighted off Vancouver Island (McGinnis and Schusterman 1981), although the breeding range does not extend to Canadian waters.

Protection

International: Northern Elephant Seals are protected from being taken or disturbed except by permit by the United States Marine Mammal Protection Act of 1972. Breeding sites are in park or military reserves. Mexico passed a law giving complete protection in 1922. International trade in Elephant Seals, their parts or derivatives is regulated by the listing of the species under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The

*Not in jeopardy in Canada — NIAC (Not In Any COSEWIC category) April 1986.

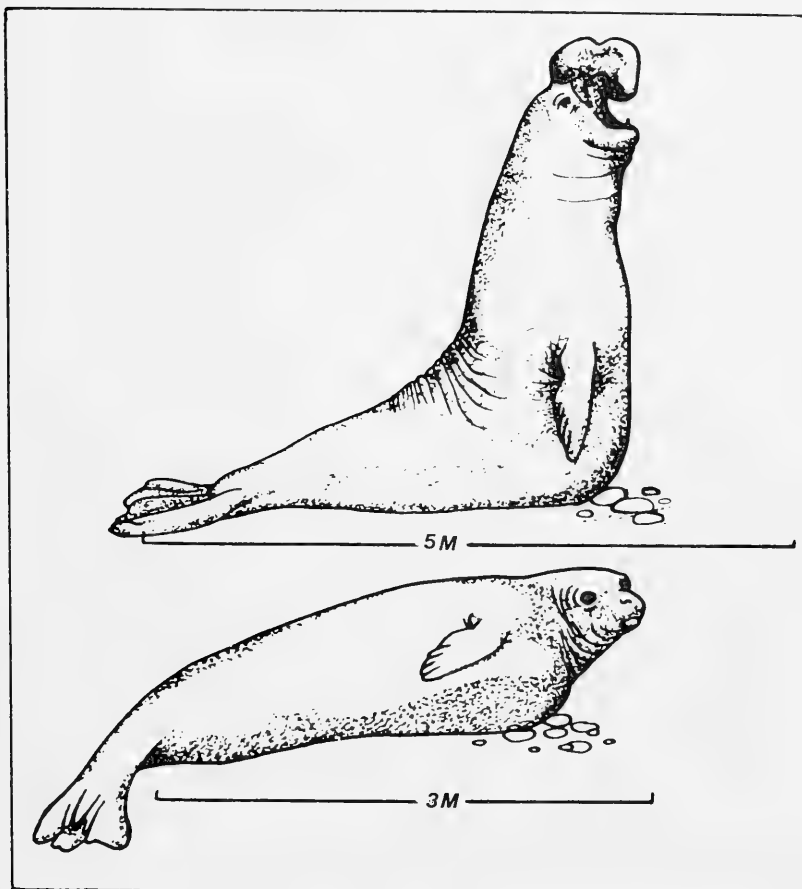


FIGURE 1. Northern Elephant Seal, *Mirounga angustirostris*. The male (above) is depicted in an aggressive posture with the proboscis inflated; the female is shown below (adapted from Gaskin 1972).

United States has proposed that the species be delisted and Canada is in agreement with this proposal.

Protection of rookeries from disturbance during breeding season by controlling human access is important to maintain pup survival. The remote nature of most rookeries and the federal jurisdiction over most islands seems to be sufficient to minimize disturbance.

National: Northern Elephant Seals are protected in Canada under the Fisheries Act. These seals are not hunted in Canada.

Population Size and Trends

Northern Elephant Seals were a prime species for the commercial sealers of the 19th century because of a

thick layer of subcutaneous fat which could yield copious quantities of oil (up to 350 L from a single bull; Scammon 1874). By 1860, the species was virtually exterminated and stayed at a very low level, probably fewer than 100 individuals, throughout the rest of the century (Bartholomew and Hubbs 1960).

Since the early 1900s, the species has been increasing exponentially. Elephant Seals received protection from Mexico in 1922 and began to expand their range from their Isla de Guadalupe refuge by the 1930s. In 1978, the total population was estimated to be over 60 000, including almost 15 000 pups produced (Bonnell et al. 1980).

Cooper and Stewart (1983) calculated an annual growth rate for the entire species between 1965 and 1977 of about 8.3 percent and perhaps greater towards

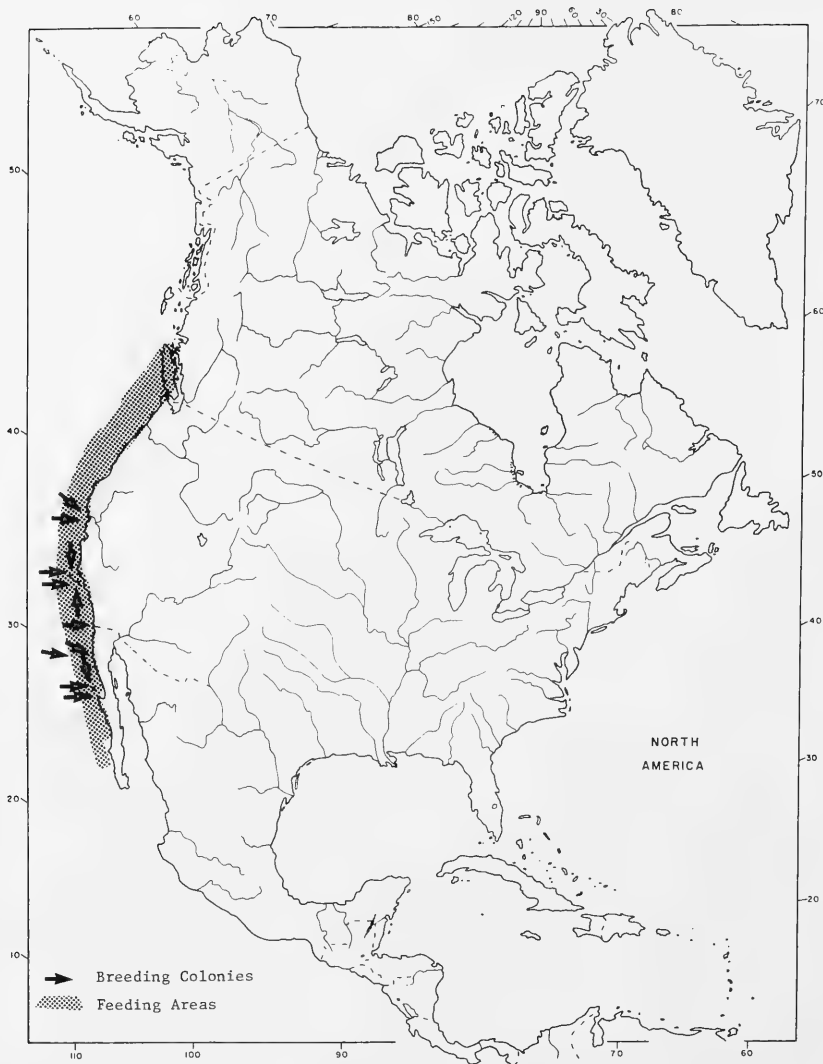


FIGURE 2. Distribution of the Northern Elephant Seal.

the end of that period and in more recent years. They estimated total pup production for 1982 to be about 23 000 which makes the total population size in 1982 about 100 000. The world population is still increasing, although at different rates on different rookery islands. The annual increase for the past 10-20 years has averaged 14% with no indication of decrease (Cooper and Stewart 1983). Factors limiting growth rate, dispersal, or ultimate carrying capacity size are not sufficiently understood to predict when population growth may level off.

Habitat

Preferred breeding areas are sandy beaches (LeBoeuf and Bonnell 1980) and the location of breeding areas seems to be related to ease of access by gravid cows. Overcrowding and social interactions may cause young animals to pup on less preferable cobble beaches or to establish new rookeries on island, or more recently, mainland beaches. On some islands, available breeding space is considered filled; on others there is room for expansion. Decimation of mainland terrestrial predators and protection from

human harassment may allow further colonization of the mainland for pupping. Census data have been found to correlate with fluctuations in salinity, water temperature, coastal upwellings and food supply (Le Boeuf et al. 1974).

Northern Elephant Seals probably dive much deeper than sea lions (*Zalophus californianus*, *Eumetopias jubatus*), and the prey of the species are largely deepwater marine fish and squid (McGinnis and Schusterman 1981). This suggests that they avoid competition with sea lions and other seals by exploiting a food niche which is unavailable to the other pinnipeds.

General Biology

Female Northern Elephant Seals usually pup first at age three or four, and infrequently at age two (Bonnell et al. 1980). Physical maturity is reached at six years of age. Females have one pup annually, usually in the same rookery, until death at around age 14. Males mature sexually at about age five but usually do not successfully mate until eight or nine. They are highly polygamous. Peak breeding success for males is achieved at age 10 or 11, and most die by 14. Pup mortality before weaning varies widely between rookeries and years, seemingly due primarily to varying weather and seal densities at different rookeries: 3 to 8 percent for 1979 to 1982 at San Miguel (Cooper and Stewart 1983); 13 to 40 percent for 1978 to 1979 at Ano Nuevo Island (LeBoeuf and Bonnell 1980); 7 to 71 percent for 1974 to 1977 at the Farallon Islands (Ainley et al. 1978). Pupping and breeding space may regulate population levels before food does. Neither age-specific mortality rates for seals older than pups nor fecundity rates have been published.

Animals disperse pelagically from rookeries to the feeding areas. Northern Elephant Seals migrate primarily northward from their breeding sites to Canada or even Alaska, but also to the south along Baja California (Condit and LeBoeuf 1984). Adult males and juvenile males and females migrate long distances but adult females may remain near their breeding sites. Elephant Seals feed on numerous cephalopod species and several fish, shark and skate species. They feed in deep-water, offshore areas, such as over shelf slopes and seem to favour schooling species of squid and fish. They appear to move solitarily unless an abundant food source attracts several together (Antonelis and Fiscus 1980). Several Elephant Seals have been caught in set fishing gear (Condit and LeBoeuf 1984). Besides these few reports of incidental take, interactions of Elephant Seals with commercial fisheries are poorly known. Some competition may occur either for schooling species

such as market squid, *Loligo opalescens*, or for benthic species taken by longline fisheries. No significant competition or incidental take problem is known.

Beach populations reach their lowest levels in August. By November, younger animals return to commence breeding before the adults, whose populations on the breeding colonies peak in February, followed by another juvenile peak in April-May (McGinnis and Schusterman 1981). The females pup, nurse, wean and leave their young within 34 days of arrival. The females feed at sea, return to moult and then depart on the feeding migration to follow the bulls which have already departed. The pups remain on the beach for about a month, learning to swim and dive before they commence their migration.

Limiting Factors

The protection afforded the species and their breeding sites has allowed the Northern Elephant Seal to increase on a logarithmic basis. Factors limiting growth rate, dispersal and ultimate carrying capacity are not known.

Pollution, oils spills, etc., could limit populations, especially on the breeding sites, through direct effects on the animals themselves or through effects on the food supply.

Special Significance of the Species

Elephant Seals were once in high demand for the oil produced from the subcutaneous fat and for their genitalia for medicinal use. However, the wholesale slaughter of these animals in the 1800s rendered populations too low for commercial interest, and since that time other products have become available to replace seal oil as an economic commercial product. Today utilization of these seals is restricted to a very few specimens taken under scientific permits and a few taken incidentally by commercial fishermen. No commercial trade exists.

The number of live specimens in trade for scientific or display purposes is very low. Demand for live specimens can probably be filled by stranded animals that have been rehabilitated but cannot be released to the wild.

Northern Elephant Seals are similar in appearance and behaviour to Southern Elephant Seals. The latter is a southern hemisphere species that numbers some 600 000 animals, distributed in the sub-Antarctic and southwest Atlantic. The southern species also repopulated after severe decimation by sealers in the 1800s and is clearly no longer endangered.

Evaluation

Protection of Northern Elephant Seals and their breeding sites has allowed them to initiate and

maintain a logarithmic rate of population recovery throughout their historic range. No commercial value or trade is known, nor is there any significant competition with humans or other species for food. Active research programs, several of them long-term, are ongoing at several sites to examine various aspects of their population biology. Their population levels are being monitored at all established breeding areas. Delisting of the species from CITES Appendix II should not reduce current protection activities.

Current population levels suggest the species is neither rare nor endangered.

Acknowledgments

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Literature Cited

- Ainley, D. G., H. R. Huber, S. Morrell, and R. H. LeValley. 1978. Studies at the Farallon Islands, 1977. Final Report to U.S. Marine Mammal Commission, Washington, D.C. [Contract MLM4AC002.]
- Antonelis, G. A., Jr., and C. H. Fiscus. 1980. The pinnipeds of the California current. California Cooperative Oceanographic Fishery Investigation Reports 21: 68-78.
- Antonelis, G. A., Jr., S. Leatherwood, and D. K. Odell. 1981. Population growth and censuses of the northern elephant seal, *Mirounga angustirostris*, on the California Channel Islands, 1958-1978. Fisheries Bulletin (U.S.) 79(3): 526-567.
- Bartholomew, G. A., and C. L. Hubbs. 1960. Population growth and seasonal movements of the northern elephant seal, *Mirounga angustirostris*. Mammalia 24(3): 312-324.
- Bonnell, M. L., B. J. LeBoeuf, M. O. Pierson, D. H. Dettman, G. D. Farrens, C. B. Heath, R. F. Gantt, and F. J. Larsen. 1980. Pinnipeds of the Southern California Bight. In Marine mammal and seabird surveys of the Southern California Bight area, 1975-1978. Volume 3 — Investigator's reports, Part I. National Technical Information Service PD81-248-71.
- Condit, R., and B. J. LeBoeuf. 1984. Feeding habits and feeding grounds of the northern elephant seal. Journal of Mammalogy 65(2): 281-290.
- Cooper, C. F., and B. S. Stewart. 1983. Demography of northern elephant seals, 1911-1982. Science 219: 969-971.
- Gaskin, D. E. 1972. Whales, dolphins and seals. Heinemann, Toronto.
- LeBoeuf, B. J., and M. L. Bonnell. 1980. Pinnipeds of the California Islands: abundance and distribution. Pages 475-493 in The California Islands: proceedings from a multidisciplinary symposium. Edited by D. Power. Santa Barbara Museum of Natural History, Santa Barbara, California.
- LeBoeuf, B. J., D. G. Ainley, and T. J. Lewis. 1974. Elephant Seals on the Farallones: population structure of an incipient breeding colony. Journal of Mammalogy 55: 370-385.
- McGinnis, S. M., and R. J. Shusterman. 1981. Northern Elephant Seal (*Mirounga angustirostris*). Pages 329-349 in Handbook of Marine Mammals. Edited by S. H. Ridgway and R. J. Harrison. Volume 2. Seals. Academic Press, New York.
- Scammon, D. M. 1874. The marine mammals of the northwestern coast of North America. John H. Charman and Co., San Francisco.

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Status of the Beluga, *Delphinapterus leucas*, in the Beaufort Sea*

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Belugas are found in the Beaufort Sea between May and September and they concentrate in the Mackenzie River estuary from late June to early August. In late summer they are widely distributed in the offshore waters of the eastern Beaufort Sea and Amundsen Gulf. Estimates from offshore aerial survey data indicate that there are over 11 500 whales in the population. The relationship of the "eastern Beaufort Sea" stock of Belugas to other stocks of Belugas in the Bering and Chukchi seas is not known but they occupy discrete summer ranges. It is suggested that Beaufort Sea whales should be treated as a distinct stock for management purposes. The estuary of the Mackenzie River appears to be of critical importance to the Beaufort Sea Belugas. Within the estuary, the whales utilize two main concentration areas, one in Niakunak Bay and the other in Kugmallit Bay; a third, used by smaller numbers of whales, is located near Kendall Island. About 130 Belugas are landed each year by hunters in the Mackenzie Delta area. Belugas are also taken by Inuit hunters in Alaska during the spring migration, but the magnitude of the catch is not well known. Allowing for loss rates, the total annual kill of about 300 from aboriginal hunting appears to fall within the sustainable yield of the population. The potential for increasing hunting activity, increasing levels of industrial activity and the proposed damming of the Liard River all pose potential long-term threats to the stability of the Beluga population. Continued monitoring of the population is therefore warranted.

Les bélugas parcourent la mer de Beaufort entre mai et septembre et se rassemblent dans l'estuaire du fleuve Mackenzie de la fin juin au début d'août. À la fin de l'été, ils se dispersent au large dans la partie est de la mer de Beaufort et dans le golfe Amundsen. Des recensements aériens effectués au large indiquent que la population est formée de plus de 11 500 baleines. On ne sait pas quel rapport existe entre la population de bélugas de "l'est de la mer de Beaufort" et d'autres populations de bélugas se trouvant dans les mers Tchouktche et de Béring, mais ils occupent au cours de l'été des territoires distincts. Il est proposé que les bélugas de la mer de Beaufort soient considérés comme population distincte à des fins de gestion. L'estuaire du fleuve Mackenzie semble revêtir une importance capitale pour les bélugas de la mer de Beaufort. À l'intérieur de l'estuaire du Mackenzie on trouve deux grandes concentrations de baleines, l'une dans la baie Niakunak et l'autre dans la baie Kugmallit; une troisième zone, fréquentée par un plus petit nombre de baleines, est située près de l'île Kendall. Les chasseurs de la région du delta de la rivière Mackenzie ramènent à terre chaque année environ 130 bélugas. Les chasseurs inuits de l'Alaska en capturent un plus petit nombre au cours de la migration printanière mais les chiffres même ne sont pas reconnus. Si l'on tient compte des pertes, le prélèvement annuel d'environ 300 individus par les autochtones semble se situer en deçà du rendement soutenu de la population. Cependant, la possibilité que la chasse et les activités industrielles s'intensifient de même que l'endiguement prévu de la rivière Liard constituent des menaces éventuelles à long terme pour la stabilité de la population de bélugas. Une surveillance continue de la population s'avère par conséquent justifiée.

Key Words: Beluga, White Whale, *Delphinapterus leucas*, population size and trend, Beaufort Sea.

The Beluga or White Whale, *Delphinapterus leucas*, is a toothed whale with a discontinuous circumpolar range. Adult animals (Figure 1) are usually solid white in colour and the name is said to come from the Russian *byely* = white. The calves are dull brown at birth and the colour lightens from bluish gray to white as the animal matures at about six years. These animals may reach a maximum length of 5 to 6 metres and weights of up to 1.6 tonnes. The males are usually larger than the females. These animals are typically found in the Arctic and sub-arctic seas in close association with the ice and often travel in herds of up to 100 or more individuals.

Distribution

Populations in the North American Arctic are separated into eastern and western groups by a longitudinal gap (approximately 100°-120° W) of ice-covered waters in the Canadian Arctic archipelago. Belugas in the western Arctic undertake considerable migrations between their summering grounds in the Canadian Beaufort Sea and Amundsen Gulf and wintering grounds in the Bering Sea. These whales occur in the Beaufort Sea from about mid-May to mid-September and concentrate in the Mackenzie River estuary between late June and early August (Fraker 1980; Fraker and Fraker 1981; Norton-Fraker and Fraker 1982). In late summer, they are widely distributed in the offshore waters of the Beaufort Sea (Davis and Evans 1982). The westward migration in September appears to be offshore (Davis and Evans 1982), primarily along the margin of the

* Reviewed by COSEWIC and found not to be in any COSEWIC category (NIAC) April 1985.

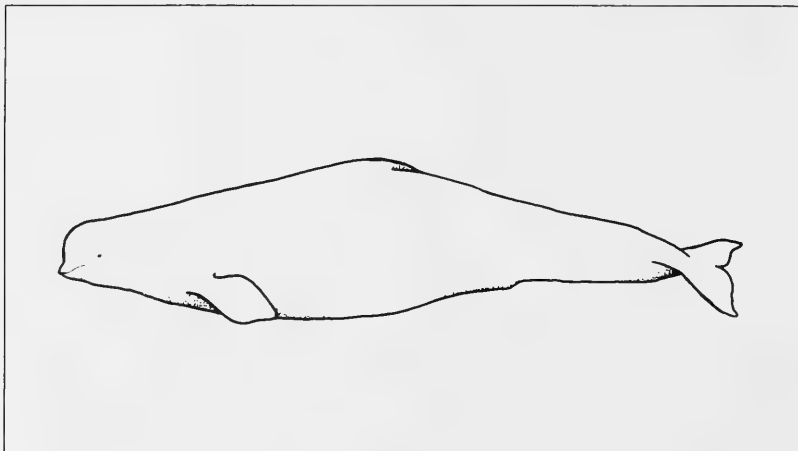


FIGURE 1. Beluga, *Delphinapterus leucas*.

polar pack ice off the Alaskan Beaufort Sea coast (L. Lowry, Alaska Department of Fish and Game, personal communication), although there are limited sightings from nearshore areas (Johnson 1979). By November and December most Belugas have returned to the Bering Sea (Burns et al. 1981; Seaman and Burns 1981).

The wintering areas of Belugas in the Bering Sea are imperfectly known but they may share common grounds with animals from other stocks that summer along the Alaskan and Soviet coasts of the Chukchi and Bering seas (Seaman and Burns 1981). Spring migration of the Beaufort Sea Belugas past Point Barrow, Alaska, begins in late April. Peak numbers usually occur at Point Barrow in mid-May. From Point Barrow the whales move eastward through offshore leads in the permanent pack ice. They begin to arrive in the extensive lead system along the west coast of Banks Island in mid to late May (Fraker 1979; Figure 2). These early arriving animals may move south into Amundsen Gulf. Belugas are seen passing Point Barrow until early June and these late-migrating animals may move closer to the coast *en route* to the Mackenzie estuary.

Various lines of evidence have been used to demonstrate stock discreteness in Belugas. Geographic discontinuity and site affinity are evident for many populations, especially on their summering grounds. Morphometric data have been used to demonstrate discreteness of several stocks (Sergeant and Brodie 1969). Mitchell and Reeves (1981) and Finley et al. (1982) argued that site tenacity and apparent lack of recruitment in two depleted Beluga populations in the eastern Arctic were sufficient evidence for treating certain stocks as discrete units.

The relationship of the Beaufort Sea Belugas to populations in coastal waters of the Bering and Chukchi seas is not known, but in summer they are separated by several hundred kilometres from the nearest group that summers in Alaskan waters. They evidently share common wintering grounds but at least part (or most) of the population is already moving toward the summering grounds during the breeding season in April–May. There is no evidence to suggest that animals move between the eastern Beaufort Sea and the eastern high Arctic.

In the absence of more direct evidence such as tagging, it is reasonable to treat the Belugas of the Beaufort Sea as a distinct stock for management purposes. Fraker (1980) has called this population the “Mackenzie” stock after the estuary used in summer by the animals. Davis and Evans (1982) suggested that the population might more properly be called the “eastern Beaufort Sea” stock, which we have shortened to the “Beaufort” stock.

Protection

In 1949 the first “Regulations for the Protection of Belugas” were introduced under the Fisheries Act of Canada. These regulations prohibited the capture or hunting of Belugas without a licence in Hudson Bay, Hudson Strait, James Bay and Ungava Bay; native people were exempted if the whales were used for domestic purposes or as food for their dogs. These regulations coincided with the opening of a substantial commercial Beluga fishery at Churchill, Manitoba (Doan and Douglas 1953; Kemper 1980). Further regulations were introduced between 1962 and 1965 to regulate and stimulate the development of “sport” hunting of Belugas along the west coast of

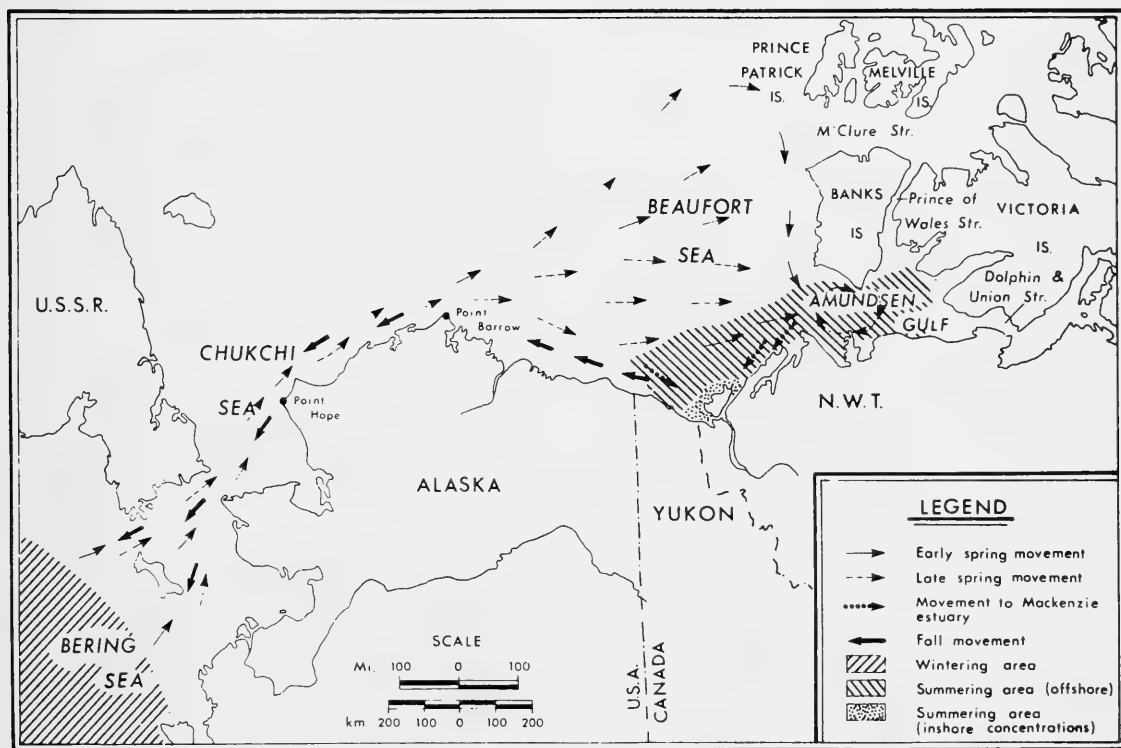


FIGURE 2. Geographical locations and seasonal range of the Beaufort Beluga population (after Fraker 1980).

Hudson Bay. Sport hunting was subsequently discontinued. Present regulations allow indigenous people to hunt Belugas for subsistence purposes, with the restriction that they are first required to attach harpoons to whales before they kill them and that they not kill females attended by calves. These regulations are essentially unenforceable (R. Moshenko, Department of Fisheries and Oceans, personal communication).

In 1979, the Scientific Committee of the International Whaling Commission (IWC) evaluated the available information on world stocks of Belugas and recommended that a cooperative research program be instituted by the USA, Canada and the USSR to begin to evaluate the interrelationships and status of stocks of Belugas that occupy the Bering Sea and migrate into the Beaufort and Chukchi seas (IWC 1980). This recommendation has not been acted upon, although the Americans have initiated a tagging program to look at interrelationships of Belugas that summer along the Alaskan coast (Lowry et al. 1982). In 1981, the Canadian government withdrew as a member of the International Whaling Commission.

Population Size and Trends

The Belugas' use of the Mackenzie estuary has been studied since 1972 when Esso Resources Canada Limited began a long-term monitoring program (see Fraker and Fraker (1979, 1981) and Norton-Fraker and Fraker (1982) for details). The estimated maximum numbers of Belugas (excluding neonates) using the Mackenzie estuary have ranged between 3500 and 7000 in the seven years from 1976 to 1982. The variation in estimates is largely due to variable survey conditions and survey coverage (Norton-Fraker and Fraker 1982). These authors suggested that probably not all of the population used the estuary in any one summer.

Davis and Evans (1982) surveyed much of the offshore area of the eastern Beaufort Sea and Amundsen Gulf in late July and August 1981 (after the main period of estuarine occupation) and found Belugas widely distributed in the survey area. Based on the results of surveys between 5 and 17 August, they estimated that at least 11 500 Belugas were present in the offshore waters of the eastern Beaufort Sea. They used conservative procedures and believed

that 11 500 was a minimum estimate of the size of the "eastern Beaufort Sea" population.

Hunting by aboriginal peoples is the major source of mortality to Belugas. Most of the hunting pressure on the Beaufort Belugas is directed at those whales utilizing the shallow waters around the Mackenzie delta in July and early August. In this area the average annual landed catch of Belugas between 1972 and 1980 was 131 animals (Fraker and Fraker 1982). In addition, in the Mackenzie estuary, Fraker (1980) reported that roughly one third of the kill is lost. Seaman and Burns (1981) report a similar loss rate for Belugas hunted in Alaskan waters. Hunt (1979) estimated a loss rate of 40% in the Mackenzie estuary. Thus, hunting mortality estimates based on landed catches alone are undoubtedly low. Applying the above loss rates to the average landed catch of 131 yields an average kill of 197 to 218 whales. Elsewhere in the Canadian Beaufort region, an additional 10+ Belugas may be landed every year (Fraker 1980).

The losses during the spring ice-edge hunt off northwestern Alaska are apparently higher than in the Mackenzie estuary. Fraker (1980) estimated that about 60 (including struck and lost animals) are killed per year at the ice-edge hunt. It is not known whether the Beaufort Sea Belugas are also hunted by the Siberian Inuit. Even allowing for loss rates, the total kill of about 300 from aboriginal hunting appears to be well within the sustainable capabilities of a population estimated at over 11 500 (see section on Reproductive Capability).

Norton-Fraker and Fraker (1982) looked for evidence of fundamental changes in the length-frequency distribution and sex composition of the Belugas taken in the Mackenzie delta and tentatively concluded that there was no indication of population instability caused by hunting. However, hunters exercise strong biases in selecting animals, as pointed out by the authors, and statistics on the length and sex composition of the harvest would be insensitive to anything but very drastic changes in the population.

Habitat

The attraction of Belugas to certain estuaries in midsummer is a well known and spectacular phenomenon. Since the calving season of Belugas coincides with their occupation of estuaries, it has been hypothesized (and widely accepted) that the warmer estuarine environment confers a thermal advantage to newborn calves (Sergeant 1973). Fraker et al. (1979) suggested that the warmer estuarine waters conferred a thermal advantage on all age classes, not just calves. Calving has not actually been observed to take place in the estuaries in spite of extensive observational programs (Finley 1976;

Sergeant and Hay 1979). In fact, calving appears to take place in offshore waters (Finley 1976, 1982). Finley (1982) suggested that estuaries served a dual function — a warm nursery and a place to moult. He noted that whatever the purpose, the estuarine habit of the Beluga is highly site-traditional and apparently critical in the life scheme of the species. Belugas have occupied the Mackenzie estuary for hundreds of years and have figured significantly in the development of the local hunting culture (McGhee 1974). Fraker et al. (1979) and Norton-Fraker and Fraker (1982) have documented recent patterns of use of the Mackenzie estuary and have outlined two main concentration areas, one in Niakunak Bay and the other in Kugmallit Bay; a third, used by smaller numbers of whales, is located near Kendall Island (Figure 3).

Beluga movements and distribution are often dictated by ice conditions. In some areas, they depend on very limited but predictable flaw features of ice that allow them to overwinter in areas far removed from extensive open water (Jonkel 1969; Finley and Renaud 1980). Belugas in the Beaufort Sea are dependent on the early and predictable development of a flaw lead system that gives them access to the Beaufort Sea (Fraker 1979).

General Biology

Reproductive Capability

Interpretation of age-specific reproductive parameters of Belugas is based on limited evidence for ageing criteria, namely, that two dentinal layers are deposited annually (Brodie 1969; Sergeant 1973). Brodie (1971) found that female Belugas reached sexual maturity when 9-10 tooth layers were present. Sergeant (1973) found that male Belugas from western Hudson Bay matured at 16-18 dentine layers, whereas Brodie (1971) found that in Cumberland Sound all males with more than 14 dentine layers were mature.

Conception occurs in early May, gestation lasts 14.5 months and calving occurs in late July and early August at Cumberland Sound (Brodie 1971). Lactation lasts about two years and females produce a single calf about once in three years (Brodie 1971; Sergeant 1973). Sergeant (1973) found that 41% of all mature females taken at Whale Cove were pregnant in late summer when conception had ceased. At this rate, mature females become pregnant once in 2.4 years on average but actual birth rates would be somewhat less than 0.41 per mature female per year, and Brodie (1971) assumes it to be about 0.33 calves per female per year.

Sergeant (1973) calculated the gross annual production of calves of a Beluga population in Hudson Bay to be 12%, but this was based on questionable assumptions about the stability of the

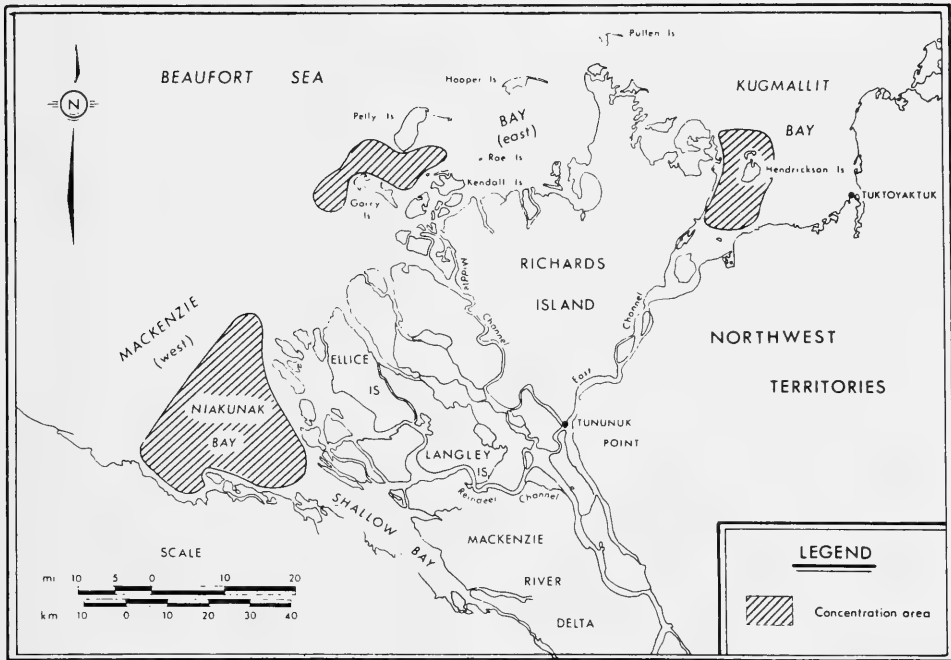


FIGURE 3. Geographical extent of Beluga concentration areas in the Mackenzie estuary (after Fraker 1980).

population (IWC 1980: 119). Sergeant's estimate is in agreement with observed frequencies of newborn calves in the high Arctic after calving was thought to be complete (Finley 1976). Brodie (1971) roughly calculated a theoretical instantaneous recruitment rate of 9%. Recruitment to the breeding population is undoubtedly less than 9-12% but nothing is known about age-specific mortality rates. Sergeant (1981) has argued that a safe estimate of sustainable yield for monodontid whales would be 5%. The Scientific Committee of the IWC evaluated the evidence for this estimate and concluded that it was inadequate as a 'rule-of-thumb' estimate of sustainable yield for Beluga populations (IWC 1982).

Migration

The Beaufort Belugas cover a round-trip distance of about 5000 km between their summering and wintering areas. Fraker (1980) has outlined the migration routes (Figure 2).

Behaviour/Adaptability

Belugas are often highly gregarious, travelling in large, dense herds during migration or occurring in concentrations in estuaries in mid summer. In late summer they may be found widely dispersed in small groups in offshore waters of the Beaufort Sea

although herds of several hundred are often seen (Davis and Evans 1982). It is this gregarious behaviour that has frequently resulted in heavy mortality, as herds can easily be driven into shallow waters and slaughtered. Such hunting mortality marks the history of several depleted stocks of Belugas.

Within the herds, the males often form discrete, cohesive "bachelor pods" while females with their young occur in more loosely organized groups (Heyland 1974; Finley et al. 1982). Based on the behaviour of other odontocete whales, Belugas are thought to be polygamous (i.e. one male breeds with several females). The maternal bond is long in the Beluga; lactation lasts for over a year and sub-adults may still accompany the mother even after she has given birth again (i.e. at least three years).

Finley et al. (1982) were impressed with the persistence of Belugas in their use of particular estuaries in northern Québec, despite frequent harassment by hunters with outboard-powered canoes. Finley (1982) concluded that the estuarine behaviour of Belugas was "highly site-traditional and apparently critical in the life scheme of the species". It is not known what specific characteristics attract Belugas to certain estuaries while other apparently similar estuaries are not used.

Belugas apparently tolerate a degree of industrial disturbance since they have continued to use the mouth of the Churchill River in spite of the considerable port development there (Sergeant 1973). Beaufort Belugas react to vessel traffic (Ford 1977) but they continue to move into the Mackenzie River estuary despite the establishment of offshore drilling platforms and considerable seismic activity (Norton-Fraker and Fraker 1982; Richardson et al. 1982). Belugas in the Mackenzie estuary have been continuously studied from 1972 to 1982 (see Norton-Fraker and Fraker (1982) for summary). There has been no indication that patterns of use of the estuary have changed or that the population has declined due to the increasing industrial activity adjacent to the estuary. Brodie (1981), in addressing the issue of industrial disturbance to whales, has suggested that whales may not adapt to industrial activity but rather tolerate it because of specific ecological needs that are present in a particular area. Belugas continue to use the Saguenay estuary in the St. Lawrence River in spite of considerable vessel activity; however, the population has been declining and is now considered endangered, probably due to some combination of past over-exploitation, industrial disturbance and possible environmental contamination (Pippard 1983). Sergeant and Brodie (1975) believed that the damming of two rivers draining into the St. Lawrence had altered the heat budget sufficiently to have caused Belugas to abandon them.

Except for the brief open water season, Belugas are seldom found far from pack ice. This has been interpreted as an adaptive behaviour in response to predation by Killer Whales, *Orcinus orca* (Sergeant and Brodie 1969); however, this is difficult to interpret in the present context since Killer Whales are rare in the Bering and Beaufort seas. The ice-associated behaviour of Belugas does have physical risks, however, and large-scale mortality has occasionally resulted when Belugas have become entrapped by developing ice (Porsild 1918; Hill 1967; Freeman 1968; Kapel 1975).

Limiting Factors

Little is known about the factors that limit the growth of Beluga populations. In many areas, aboriginal hunting figures significantly in the mortality of this species. In the Canadian Beaufort Sea, the Beluga mortality caused by hunting appears to fall well within the sustainable yield of the population. Killer Whales and Polar Bears, *Ursus maritimus*, are insignificant predators of Belugas. Ice entrapment occasionally accounts for large-scale mortality but this appears to be a random event of rare occurrence. In 1966, for example, about 20 Belugas

died when they became entrapped by ice in the Eskimo Lakes (Hill 1967).

Although the Beluga is an opportunistic feeder, its diet broadly overlaps that of several other species of marine mammals, especially pinnipeds found on its Bering sea wintering grounds (Seaman et al. 1982). Limitation of the Beaufort stock through competition for food with other marine mammals appears to be a possibility. In addition, developing commercial fisheries in the Bering Sea are taking large amounts of fish that are used by several species of marine mammals; the available information indicates that "a relatively high probability of interaction" exists between these fisheries and Belugas (Lowry 1982: 308).

Belugas appear to be highly dependent on access to certain traditional estuaries. The specific benefits of this estuarine occupation are not clearly known but it may be related to thermal advantage for new-born calves and/or moulting of the epidermis. Whatever the purpose, this behaviour is highly site-traditional and apparently important to the species. Loss of estuarine habitat or exclusion of Belugas from traditional estuaries would probably have a significant negative impact on the Beluga population that utilizes the Mackenzie estuary. Considerable industrial activity by the oil industry has already occurred in, and adjacent to, those parts of the Mackenzie estuary that are utilized by the Beluga. However, no detrimental effects have been noted to date (Norton-Fraker and Fraker 1982). A proposed hydro-electric development by B.C. Hydro on the Liard River (a major source of the Mackenzie River) may significantly affect those physical/chemical properties of the outflow that are significant to the survival of the Beluga.

Special Significance of the Species

Among odontocetes, Belugas and Narwhals, *Monodon monoceros*, share a unique pagophilic (ice-loving) existence. Both species give birth in arctic waters and are protected from extreme cold by a thick blubber layer. The estuarine habit of the Beluga is unique and is of interest to those studying adaptive mechanisms of cold water mammals. The estuarine habit of the Beluga also commands considerable public attention because it is a spectacular phenomenon that can be easily viewed from shore. It attracts many visitors to the Churchill and Saguenay rivers. Photographs of estuarine concentrations of Belugas have been frequently used in many publications to attract public interest in whales.

Throughout much of their circumpolar range, Belugas are hunted by native people (usually Inuit) primarily for subsistence purposes. The Beluga is

highly valued for its skin or muktuk, which is considered a delicacy when eaten raw. Due to advances in hunting technology, some populations such as those in Cumberland Sound and Northern Quebec are being heavily exploited. International (IWC) concern is increasingly focused on this "subsistence" hunt at a time when the Inuit are becoming more ethnically self-aware and politically assertive. Since the Inuit are a hunting society, one of their primary concerns is to assert their authority over the primary resource base. Wildlife management and conservation groups interested in the protection of the Beluga may not fully appreciate the management problems associated with an animal that moves across various political, bureaucratic and ideological boundaries.

Evaluation

The Belugas of the Beaufort Sea are experiencing major increases in the level of offshore industrial activity, and the level of native hunting activity will likely be increasing in the foreseeable future. Thus far, there is no evidence that the population is suffering, although several parameters are inadequately known. However, increased levels of industrial activity around the delta, the increased potential for an oil spill, and the proposed damming of the Liard River all pose threats to the stability of the Beaufort Beluga stock. The Beaufort stock is only one of several stocks of Belugas that are facing increased industrial and hunting activity in the Canadian Arctic. Although there is no evidence that the Beaufort Belugas are suffering a decline, special attention should be given to the potentially deleterious developments that may occur in, and adjacent to, the Mackenzie estuary.

Presently, the status of the eastern Beaufort Sea stock of Belugas can best be described as healthy.

Acknowledgment

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Literature Cited

- Brodie, P. F.** 1969. Mandibular layering in *Delphinapterus leucas* and age determination. *Nature* 221: 956-958.
- Brodie, P. F.** 1971. A reconsideration of aspects of growth, reproduction, and behaviour of the white whale (*Delphinapterus leucas*), with reference to the Cumberland Sound, Baffin Island, population. *Journal of the Fisheries Research Board of Canada* 28: 1309-1318.
- Brodie, P. F.** 1981. Energetic and behavioural considerations with respect to marine mammals and disturbance from underwater noise. Pages 287-290 in *The question of sound from icebreaker operations: the proceedings of a workshop*. Edited by N. M. Peterson. Arctic Pilot Project, Petro-Canada Exploration, Inc., Calgary.
- Burns, J. J., L. H. Shapiro, and F. H. Fay.** 1981. Ice as marine mammal habitat in the Bering Sea. Pages 781-797 in *The eastern Bering Sea shelf: oceanography and resources*. Edited by D. W. Hood and J. A. Calder. Office of Marine Pollution Assessment, NOAA, Seattle.
- Davis, R. A., and C. R. Evans.** 1982. Offshore distribution and numbers of white whales in the eastern Beaufort Sea and Amundsen Gulf, summer 1981. Report by LGL Limited, Toronto, Ontario, for Sohio Alaska Petroleum Company, Anchorage, Alaska, and Dome Petroleum Limited, Calgary, Alberta. Sohio, Anchorage.
- Davis, R. A., and K. J. Finley.** 1979. Distribution, migration, abundance and stock identity of eastern Arctic white whales. Report of the International Whaling Commission, Cambridge (IWC Doc. SC/31/Sm10).
- Doan, K. H., and C. W. Douglas.** 1953. Beluga of the Churchill region of Hudson Bay. *Bulletin of the Fisheries Research Board of Canada* Number 98.
- Finley, K. J.** 1976. Studies of the status of marine mammals in the central District of Franklin, N.W.T., June-August 1975. Report by LGL Limited for Polar Gas Project, Toronto.
- Finley, K. J.** 1982. The estuarine habit of the beluga or white whale *Delphinapterus leucas*. *Cetus, Journal of Moclips Cetological Society* 4(2): 4-5.
- Finley K. J., and W. E. Renaud.** 1980. Marine mammals inhabiting the Baffin Bay North Water in winter. *Arctic* 33: 724-738.
- Finley K. J., G. W. Miller, M. Allard, R. A. Davis, and C. R. Evans.** 1982. The belugas (*Delphinapterus leucas*) of Northern Québec: distribution, abundance, stock identity, catch history and management. Canadian Technical Report, Fisheries and Aquatic Sciences 1123.
- Ford, J.** 1977. White whale - offshore exploration acoustic study. Report by F. F. Slaney and Co. Limited, Vancouver, for Imperial Oil Limited, Calgary.
- Fraker, M. A.** 1979. Spring migration of bowhead (*Balaena mysticetus*) and white whale (*Delphinapterus leucas*) in the Beaufort Sea. Fisheries and Marine Service Technical Report 859.
- Fraker M. A.** 1980. Status and harvest of the Mackenzie stock of white whales (*Delphinapterus leucas*). Report of the International Whaling Commission 30: 451-458.
- Fraker, M. A., and P. N. Fraker.** 1979. The 1979 whale monitoring program Mackenzie Estuary. Report by LGL Limited, for Esso Resources Canada Limited, Edmonton.
- Fraker, P. N., and M. A. Fraker.** 1981. The 1980 whale monitoring program, Mackenzie Estuary. Report by LGL Limited, Sidney, British Columbia, for Esso Resources Canada Limited, Calgary, Alberta.
- Fraker, M. A., C. D. Gordon, J. W. McDonald, J. K. B. Ford, and G. Cambers.** 1979. White whale (*Delphinapterus leucas*) distribution and abundance and the relationship to physical and chemical characteristics of the Mackenzie Estuary. Canadian Fisheries and Marine Services Technical Report 863.
- Freeman, M. M. R.** 1968. Winter observations on Beluga (*Delphinapterus leucas*) in Jones Sound, N.W.T. *Canadian Field-Naturalist* 82: 276-286.

- Heyland, J. D.** 1974. Aspects of the biology of beluga (*Delphinapterus leucas*) interpreted from vertical aerial photographs. Pages 373-390 in Second Canadian symposium on remote sensing. Proceedings Volume 2. Edited by G. E. Thompson. University of Guelph, Guelph, Ontario.
- Hill, R. M.** 1967. Observations on beluga whales trapped by ice in Eskimo Lakes winter 1966/67. Report DINA, Inuvik Research Laboratory, Inuvik, Northwest Territories.
- Hunt, W. J.** 1979. Domestic whaling in the Mackenzie Estuary, Northwest Territories. Fisheries and Marine Service Technical Report Number 760.
- International Whaling Commission (IWC).** 1980. Review of definition and status of stocks of the white whales, *Delphinapterus leucas*, and the narwhal, *Monodon monoceros*. Annex I. Report of the Scientific Committee. Report of the International Whaling Commission 30: 117-125.
- International Whaling Commission (IWC).** 1982. Report of the Sub-committee on small cetaceans. Annex H. Report of the International Whaling Commission 32: 113-126.
- Johnson, S. R.** 1979. Fall observations of westward migrating white whales (*Delphinapterus leucas*) along the central Alaska Beaufort Sea coast. Arctic 32: 275-276.
- Jonkel, C. J.** 1969. White whales wintering in James Bay. Journal of the Fisheries Research Board of Canada 26: 2205-2207.
- Kapel, F. O.** 1975. Preliminary notes on the occurrence and exploitation of smaller Cetacea in Greenland. Journal of the Fisheries Research Board of Canada 32: 1079-1082.
- Kemper, J. B.** 1980. History of use of narwhal and beluga by Inuit in the Canadian eastern Arctic including changes in hunting methods and regulations. Report of the International Whaling Commission 30: 481-492.
- Lowry, F. L.** 1982. Documentation and assessment of marine mammal - fishery interactions in the Bering Sea. Transactions of the 47th North American Wildlife and Natural Resources Conference: 300-311.
- Lowry, L. F., K. J. Frost, and R. R. Nelson.** 1982. Investigations of beluga whales in coastal waters of western and northern Alaska: marking and tracking of whales in Bristol Bay. Annual Report OCSEAP NA 81 RAC 00049. Alaska Department of Fish and Game, Juneau, Alaska.
- McGhee, R.** 1974. Beluga hunters. An archaeological reconstruction of the history and culture of the Mackenzie Delta Kittigaryumiut. Report Number 13, Institute of Social and Economic Research, Memorial University of Newfoundland, St. John's, Newfoundland.
- Mitchell, E. D., and R. R. Reeves.** 1981. Catch history and cumulative catch estimates of initial population size of cetaceans in the eastern Canadian Arctic. Report of the International Whaling Commission 31: 645-682.
- Norton-Fraker, P., and M. A. Fraker.** 1982. The 1981 whale monitoring program, Mackenzie Estuary. Report by LGL Limited, Sidney, British Columbia, for Esso Resources Canada Limited, Calgary, Alberta.
- Pippard, L.** 1983. A status report on the population of St. Lawrence white whales. Report of the Canadian Committee on the Status of Endangered Wildlife in Canada, Canadian Wildlife Service, Ottawa.
- Porsild, M. P.** 1918. On 'Savssats': a crowding of arctic animals at holes in the sea ice. Geographical Review 6: 215-228.
- Richardson, W. J., C. R. Greene, J. P. Hickie, and R. A. Davis.** 1982. Review of the effects of offshore petroleum operations on cold water marine mammals. Report by LGL Limited for American Petroleum Institute, Washington, D.C.
- Seaman, G. A., and J. J. Burns.** 1981. Preliminary results of recent studies of belugas in Alaskan waters. Report of the International Whaling Commission 31: 567-574.
- Seaman, G. A., L. F. Lowry, and K. J. Frost.** 1982. Foods of beluga whales (*Delphinapterus leucas*) in western Alaska. Cetology 44: 1-19.
- Sergeant, D. E.** 1973. Biology of white whales (*Delphinapterus leucas*) in western Hudson Bay. Journal of the Fisheries Research Board of Canada 30: 1065-1090.
- Sergeant, D. E.** 1981. On permissible exploitation rates of Monodontidae. Report of the International Whaling Commission 31: 583-588.
- Sergeant, D. E., and P. F. Brodie.** 1969. Body size in white whales (*Delphinapterus leucas*). Journal of the Fisheries Board of Canada 26: 2561-2580.
- Sergeant, D. E., and P. F. Brodie.** 1975. Identity, abundance, and present status of populations of white whales (*Delphinapterus leucas*) in North America. Journal of the Fisheries Research Board of Canada 32: 1047-1054.
- Sergeant, D. E., and K. Hay.** 1979. Migratory sea mammal populations in Lancaster Sound. Arctic Island Pipeline Project Report Environmental Social Program. Department of Indian and Northern Affairs, Ottawa.
- Sergeant, D. E., and W. Hoek.** 1974. Seasonal distribution of bowhead and white whales in the eastern Beaufort Sea. Pages 705-719 in The coast and shelf of the Beaufort Sea. Proceedings of a Symposium on Beaufort Sea Coastal and Shelf Research. Edited by J. C. Reed and J. E. Slater. Arctic Institute of North America, Washington, D.C.

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Updated Status of the Sea Otter, *Enhydra lutris*, in Canada*

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An air and sea census off the west coast of Vancouver, British Columbia, in May 1984, recorded 345 Sea Otters (*Enhydra lutris*) in two colonies, the result of transplanting 89 animals from Alaska during 1969-72.

Un recensement effectué dans les airs et sur mer au large de la côte ouest de l'île Vancouver en Colombie-Britannique au mois de mai 1984, a permis de dénombrier 345 loutres de mer (*Enhydra lutris*) dans deux colonies résultant de la transplantation de 89 animaux provenant de l'Alaska entre 1969 et 1972.

Key Words: Sea Otters, *Enhydra lutris*, marine mammal, endangered species, British Columbia.

The Sea Otter, *Enhydra lutris*, was designated endangered by COSEWIC in 1978 on the basis of a status report by Munro (1985). This report summarizes the known history of the status of the species and provides an update based on recent surveys.

Distribution

Early in the eighteenth century Sea Otters (Figure 1) ranged the North Pacific littoral arc from California to the Kuriles (Figure 2). By the end of the nineteenth century the animal was approaching extinction from unregulated hunting.

1911: The Alaskan, Canadian and Californian populations were mere remnants and the governments of Japan, England, Russia and the USA agreed on their protection. There were subsequent recoveries along the Aleutian chain and off California, but it was too late for those of British Columbia.

1929: The last recorded Sea Otter seen in British Columbia waters.

1965: The author, as a member of the Marine Mammal Group at the Pacific Biological Station, Nanaimo (Fisheries Research Board of Canada), investigated the possibilities of obtaining animals from Alaska or the USSR and looked for a suitable release site in British Columbia.

1969-70-72: With cooperation between the Alaska Department of Fish and Game, the Pacific Biological Station, the British Columbia Fish and Wildlife Branch, and the Arctic Biological Station, the Fisheries Research Board of Canada, Ste. Anne de Bellevue, three transplants were made from Alaska to Checleset Bay, Vancouver Island. A total of 89

animals were released over the four-year period (Table 1; Bigg and MacAskie 1978).

1977: The Pacific Biological Station undertook air surveys, with a minimum number of 55 animals seen in Checleset Bay and 15 at Bajo Reef, some 75 km southeast.

1978: The Biology Department of the University of Victoria carried out a boat survey with a count of 51 animals in Checleset Bay and 16 at Bajo Reef (Morris et al. 1981).

1979: Changes in subtidal community structure in Checleset Bay due to Sea Otter foraging were examined by Pacific Biological Station and the British Columbia Provincial Ecological Reserves Unit (Breen et al. 1982).

1984: A boat survey was made in Checleset Bay by the West Coast Whale Research Foundation of Vancouver, while the Pacific Biological Station and the British Columbia Fish and Wildlife surveyed by air approximately 160 km of coastline from Nootka Sound to Quatsino Sound, with detailed examinations of Checleset Bay and Bajo Reef (Canadian Hydrological Charts #3683, 3666). An estimated 196 otters in Checleset Bay and 149 at Bajo Reef were recorded in ideal weather. None were seen by air between Brooks Peninsula and Quatsino Sound, or between Kyuquot Sound and Nuchatlitz Inlet (Figure 3).

A few scattered individuals have been reported by competent observers from Barkley Sound (48°40'N) to Harvey Island (52°30'N). In adjacent U.S. waters there were approximately 80 Sea Otters off the Washington coast and 100 at the Barrier Islands, Prince of Wales Island, SE Alaska, in 1983. There are estimated total populations of 1800 off California and 121 000 in Alaskan waters (Johnson 1982).

*Endangered status originally assigned by COSEWIC April 1978 and reaffirmed in April 1986.



FIGURE 1. Adult female Sea Otter with pup (courtesy Stephanie Hewlett, Vancouver Aquarium).

Protection

Sea Otters in British Columbia are protected by the Federal Fisheries Act and the British Columbia Wildlife Act and Regulations. The species was designated endangered by COSEWIC in 1978 and was also designated endangered in British Columbia in 1980 under the British Columbia Wildlife Act.

If contraventions have occurred, they are not common knowledge and no charges have been laid.

Population Size and Trends

The composition of the original 89 animals released in Checleset Bay is shown in Table 1.

The 1984 census off Vancouver Island recorded a total of 345 animals. Assuming that these are attributable to the 1969-72 transplants, there has been an overall average annual population increase of 12%

over 12 years (1972-84). It is unlikely, however, that all otters survived from the 1969 release and the actual rate of increase may be somewhat higher. The numbers present during 1977-78 must have been underestimated, perhaps as a result of different survey techniques, visibility, etc. It should be noted that there are now two separate colonies off the British Columbia coast, 75 km apart, and future calculations may need to consider separate trends.

Comparative population growth rates by region along the eastern North Pacific are shown in Table 2.

Habitat

Much of the coastline of British Columbia offers potential habitat in terms of terrain and available food that can be used by a spreading population. There are no apparent physical barriers to movement up and

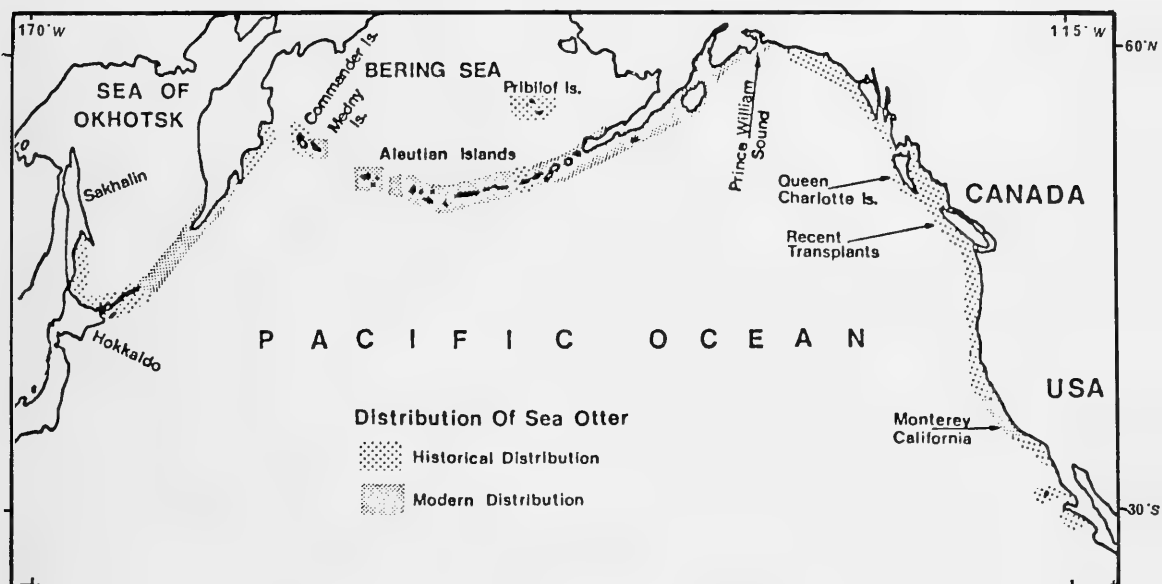


FIGURE 2. Historic and present distributions of the Sea Otter, *Enhydra lutris*.

down the British Columbia coast, and it can be expected that the animals will eventually extend their range into their historical distribution in the NE Pacific.

In 1981, Checleset Bay was established by the British Columbia Government as an Ecological Reserve (British Columbia Reserve #109). Federal Fisheries, however, have since countenanced a fishery for Geoduck Clams, *Panope generosa*, within Checleset Bay.

General Biology

Vancouver Island Sea Otters have been left relatively undisturbed since reintroduction in 1969-72, and no data on reproductive dynamics in the area have been collected. Based on U.S. studies in Alaska (Kenyon 1969), the following three observations may hold true for the Canadian population.

Reproductive Capability

1. Breeding age: It is indicated that a small percentage of females may become pregnant after three years, i.e. in their fourth year, and that animals five or more years old constitute the important reproducing segment of the population. Lifespan is 15 to 20 years.
2. Breeding frequency: total length of reproductive cycle is two years.
3. Number of young: one. Twinning is rare.

Parturition occurs in all months, reaching a peak in summer.

4. Age/sex ratio and mortality: current structure and mortality of Canadian population are unknown. At Checleset Bay only one juvenile skeleton was found (May 1984) in beach debris thrown up by winter storms.

Species Movement

Sea Otters are not migratory and movement is governed by availability of food, breeding activity and weather. Over 50% of the total population is still within Checleset Bay, 12 years after the transplants.

Behaviour

During the 1984 census in Checleset Bay, attempts to approach otters by boat were met in every case with intense scrutiny and rapid dispersal. Boat traffic is only occasional and animals were reacting with caution.

Sea Otters eat a wide variety of food items that include clams, sea urchins, mussels, crabs and fish, and they require at least 20% of their body weight in meat per day. Being primarily bottom feeders, they appear to favour depths of less than 20 fathoms and bring their catch to the surface for consumption. Short of stomach analyses, food items must be determined from direct observation or by comparing known Sea Otter feeding sites with unfrequented areas (Breen et al. 1982).

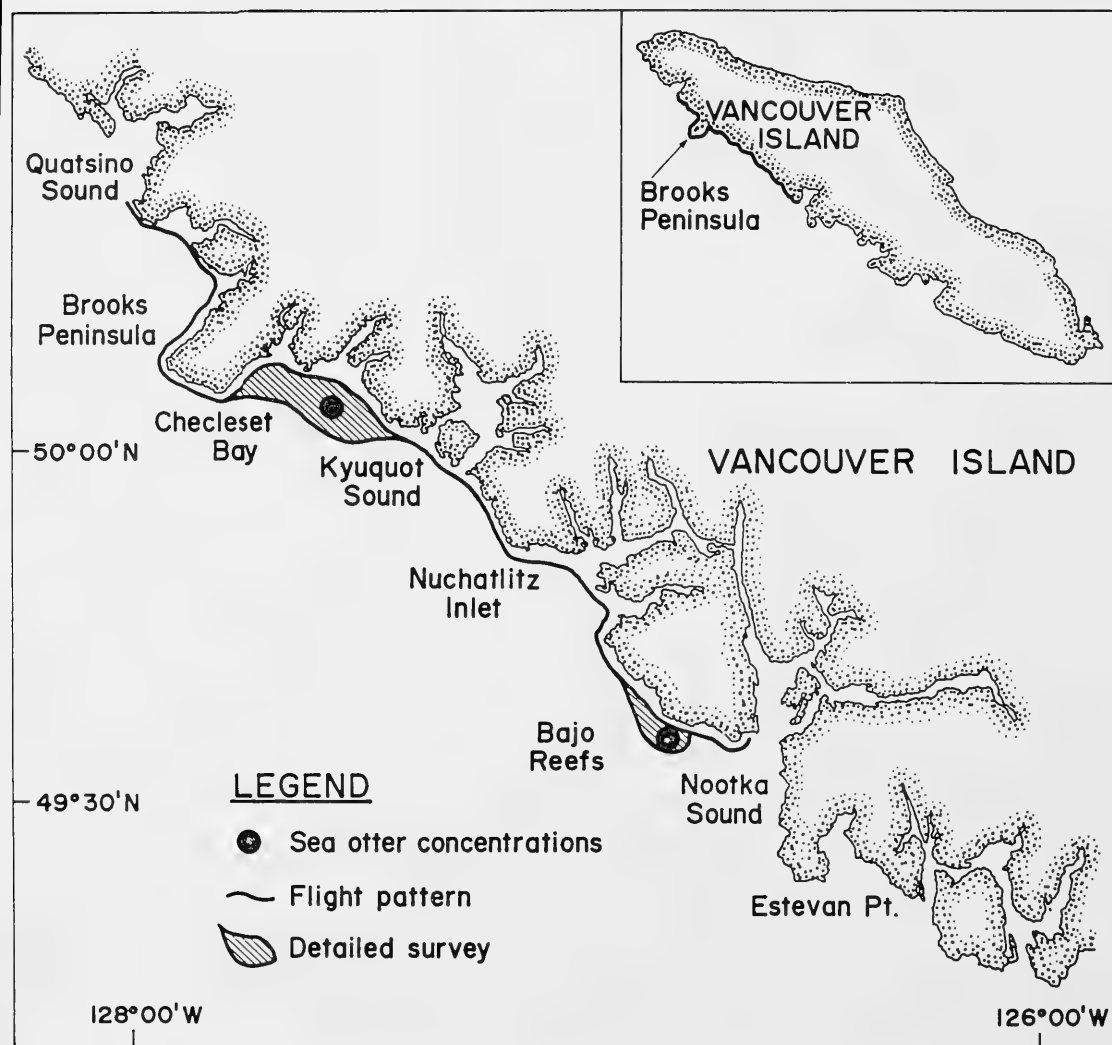


FIGURE 3. Location of two Sea Otter colonies on the west coast of Vancouver Island.

Limiting Factors

These have been minimal to date (1984) in Checleset Bay and Bajo Reef.

Habitat loss: some degradation from shell fishery.

Environment contaminations: traces of oil on some beaches.

Disturbance: increasing from summer kayak tourists and fishermen.

Species competition: not apparent.

Predation: none recorded.

Special Significance of Species

North American Status

U.S. populations in Alaska are such that there is no concern for their future. For Canada, the numbers are small and if the current rate of increase continues it could be 10 years or more before the population reaches 1000.

Public Interest

There is no doubt that the well-informed take

TABLE 1. Sex and maturity of 89 Sea Otters¹ released at Checleset Bay in three transplants from Alaska.

Transplant Date	Total	Number Released					
		Adult		Immature			
		M	F	M	F	?	
July 1969	29	9 ²	19 ²	—	—	1	
July 1970	14	6	8	—	—	—	
July 1972	46	8	22	7 ²	9 ³	—	
Total	89	23	49	7	9	1	

¹Taken from Bigg and MacAskie 1978.²Approximate.³Includes four males and two female pups.

TABLE 2. Population growth rates of Sea Otters.

Location	Date	Growth Rate	
		Intrinsic	Finite
California ¹	1938-75	0.045	4.60%
Amchitka ¹	1931-43	0.122	12.98%
Amchitka ¹	1936-43	0.192	21.17%
California ²	1914-76	0.049 - 0.058	5% - 6%
British Columbia ³	1972-84	0.113	11.95%

¹Chapman (1981).²D. J. Miller *unpublished*: A descriptive antecological model of the sea otter population in California, 1978).³1984 census.

considerable satisfaction in the re-establishment of Sea Otters on the Canadian coast. That few will manage to see them in the wild will not detract from a popular concern for their welfare. In light of the Californian and Alaskan experiences, the animals may eventually conflict with shellfish interests.

Evaluation

The present (1984) population off Vancouver Island appears vigorous, but the species should continue to be considered endangered.

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Literature Cited

- Bigg, M. A., and I. MacAskie.** 1978. Sea otters re-established in British Columbia. *Journal of Mammalogy* 59: 874-876.
- Breen, P. A.** 1984. Observations of the B.C. sea otter transplants. Manuscript Report of the Fisheries and Aquatic Sciences Number 1774. Department of Fisheries and Oceans, Fisheries Research Branch, Pacific Biological Station, Nanaimo, British Columbia.
- Breen, P. A., T. A. Carson, J. B. Foster, and E. A. Stewart.** 1982. Changes in subtidal community structure associated with the British Columbia sea otter transplants. *Marine Ecology Progress Series* 7(1): 13-20.
- Chapman, D. G.** 1981. Evaluation of marine mammal population models. Pages 277-296 in *Dynamics of large mammal populations*. Edited by C. W. Fowler and T. D. Smith. J. Wiley and Sons, New York.
- Johnson, A. W.** 1982. The sea otter (*Enhydra lutris*). Mammals in the Seas. Fisheries and Agriculture Organization, Fisheries Series Number 5. Volume IV.
- Kenyon, K. W.** 1969. The sea otter in the eastern Pacific Ocean. North American Fauna, Number 68. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife.
- MacAskie, I. B.** 1975. Sea otters. A third transplant to British Columbia. *The Beaver* (Hudsons Bay Co.), Spring 1975.
- Morris, R., D. V. Ellis, and B. P. Emerson.** 1981. The British Columbia transplant of sea otters *Enhydra lutris*. *Biological Conservation* 20: 291-295.
- Munro, W. T.** 1985. Status of the Sea Otter in Canada. *Canadian Field-Naturalist* 99(3): 413-416.

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Updated Status of the Humpback Whale, *Megaptera novaeangliae*, in Canada*

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Whitehead, Hal. 1987. Updated status of the Humpback Whale, *Megaptera novaeangliae*, in Canada. *Canadian Field-Naturalist* 101(2): 284–294.

Humpback Whales, *Megaptera novaeangliae*, are principally coastal animals found off both the east and west coasts of Canada. The eastern north Pacific population breeds in winter off Hawaii, Baja California and the Mexican mainland, and feeds in summer from Alaska to central California. The western north Atlantic Humpback Whales' principal winter breeding grounds are on Silver and Navidad banks in the West Indies, and they feed in summer from Cape Cod to West Greenland. Humpback Whales are rarely sighted off British Columbia. However, along the east coast of Canada substantial concentrations are found on the Southeast Shoal of the Grand Banks, off eastern Newfoundland, and southern Labrador, with smaller numbers off southern Newfoundland, in the Gulf of St. Lawrence, and off southwestern Nova Scotia. Population estimates in both oceans show considerable scatter, but suggest approximately 2000 animals in the eastern north Pacific, and 4000 in the western north Atlantic, both less than the estimated pre-whaling populations. It is unlikely that either population is decreasing. Humpback Whales have shown indications of adverse effects from vessel traffic and over-enthusiastic whale-watching in the Pacific, and have made drastic shifts in their distribution off Newfoundland in response to changes in prey abundance. A fisheries conflict, with Humpback Whales becoming entangled in fishermen's nets, resulted from this redistribution between 1977 and 1980. Humpback Whales are vulnerable to disturbance on their restricted breeding grounds, and to developments in fisheries, oil exploration and exploitation, and pollution in their feeding areas. The Humpback Whale is particularly significant to the whale-watching industry, and has become a focus of scientific investigation.

Le rorqual à bosse, *Megaptera novaeangliae*, qui fréquente surtout les eaux côtières, se retrouve aussi bien dans l'est que dans l'ouest du Canada. L'hiver, la population du Pacifique nord-est se reproduit au large d'Hawaï, de la Basse-Californie et du Mexique; l'été, elle se nourrit dans les eaux situées entre l'Alaska et le centre de la Californie. La population de l'Atlantique nord-ouest passe surtout l'hiver dans la région des bancs Silver et Navidad dans les Antilles, où elle se reproduit; l'été, elle se nourrit dans les eaux situées entre Cape Cod et la côte ouest du Groenland. Le rorqual à bosse se rencontre rarement au large de la Colombie-Britannique. On en trouve toutefois d'importants troupeaux sur la côte Atlantique du Canada, notamment sur le haut-fond du sud-est dans la région des Grands bancs, au large de la côte est de Terre-Neuve, et au sud du Labrador; on en a aussi observé un certain nombre au sud de Terre-Neuve, dans le golfe Saint-Laurent et au sud-ouest de la Nouvelle-Écosse. Les évaluations de la population dans les deux océans révèlent une dispersion considérable mais portent à croire qu'il y a approximativement 2000 rorquals à bosse dans le Pacifique nord-est et 4000 dans l'Atlantique nord-ouest; ces niveaux sont, dans les deux cas, inférieurs au nombre d'animaux qui composaient ces populations avant le début de la chasse. On ne croit pas que ces populations soient en baisse. Dans le Pacifique, le rorqual à bosse semble être incommodé par le trafic maritime et par certains observateurs trop enthousiastes; la population vivant au large de Terre-Neuve a, pour sa part, modifié considérablement sa répartition suite à des changements au niveau de l'abondance des proies. Cette situation a d'ailleurs donné lieu à un conflit, entre 1977 et 1980, les rorquals s'emmêlant dans les filets des pêcheurs. Le rorqual à bosse réagit mal à la perturbation de ses aires de reproduction restreintes, tout comme à la pollution, aux développements halieutiques, à l'exploration et à l'exploitation pétrolière dans ses aires d'alimentation. Le rorqual à bosse est devenu particulièrement important dans l'industrie de l'observation des baleines et fait actuellement l'objet de nombreuses études scientifiques.

Key Words: Baleen whales, Humpback Whales, *Megaptera novaeangliae*, cetaceans, North Atlantic whales, North Pacific whales, whaling.

Humpback Whales, *Megaptera novaeangliae*, are stocky members of the Balaenidae or Baleen Whales (Figure 1), which were formerly abundant in the north Pacific and north-west Atlantic. The heavy exploitation of these whales in the 19th and 20th centuries severely depleted stocks in both areas to the

extent that COSEWIC assigned both stocks a Threatened Status in 1982 (see Hay 1985). Recent investigations have indicated that the north Atlantic stock may have recovered to a substantial portion of its pre-whaling numbers, and this report updates the status for the species in light of this new evidence.

Distribution

Humpback Whales are found in all oceans. They are coastal animals and form distinct stocks on each

*Threatened status originally approved by COSEWIC 6 April 1982 (see Hay 1985). Rare status assigned for the north Atlantic stock—north Pacific stock remains Threatened (2 April 1985).



FIGURE 1. Humpback Whale, *Megaptera novaeangliae*, breaching.

side of each ocean (Mackintosh 1965). They generally migrate from warm tropical areas where they mate and calve in winter to Arctic or subarctic regions where they feed in summer. Thus Canadian waters are frequented by eastern north Pacific Humpback Whales off the West Coast, and western north Atlantic Humpback Whales off the East Coast. On both sides of the continent, Humpback Whales are principally in Canadian waters in summer (Figure 2).

The eastern north Pacific Humpback Whales have been observed from the Chukchi Sea to Mexico (Maser et al. 1981). The major wintering grounds are off Hawaii, Baja California, and the islands near Baja California, such as Socorro (Leatherwood et al. 1982). The summer range is from the Chukchi Sea to central California, with particular concentrations in southeast Alaska and the Prince William Sound area.

In summer, Humpback Whales used to be abundant off British Columbia, including the Strait of Georgia (Pike and MacAskie 1969). However, Humpback Whales are now rare in the British Columbia area (M. Bigg, personal communication). They are occasionally sighted 20 to 50 km offshore off the West Coast of Vancouver Island and around the Queen Charlotte Islands (M. Bigg, J. Darling, personal communication).

In the western north Atlantic, Humpback Whales are found from Venezuela to Greenland (Leatherwood et al. 1976). The major wintering and calving grounds are in the West Indies, particularly on Silver and Navidad banks which lie north of the Dominican Republic, although historically they bred all along the Antillean chain (Winn et al. 1975). Humpback Whales are sighted off Bermuda in springtime on migration, and feed in summer from Cape Cod to west Greenland. Particularly dense concentrations are found off Cape Cod, on the southeast shoal of the Grand Banks, off eastern Newfoundland, southern Labrador, and on Fyllas Bank off west Greenland (Kapel 1979; Katona et al. 1980; K. Lynch, unpublished data). Small numbers of Humpback Whales are also seen in some of these waters during the winter months (e.g. Williamson 1961).

In addition to the major areas mentioned above, other eastern Canadian waters contain smaller numbers of Humpback Whales: off southwest Nova Scotia (Winn 1982), on the north shore of the Gulf of St. Lawrence (Sears 1983), and in Hermitage Bay on the south coast of Newfoundland (K. Lynch, unpublished data).

In both the eastern north Pacific and the western north Atlantic Humpback Whales are found in

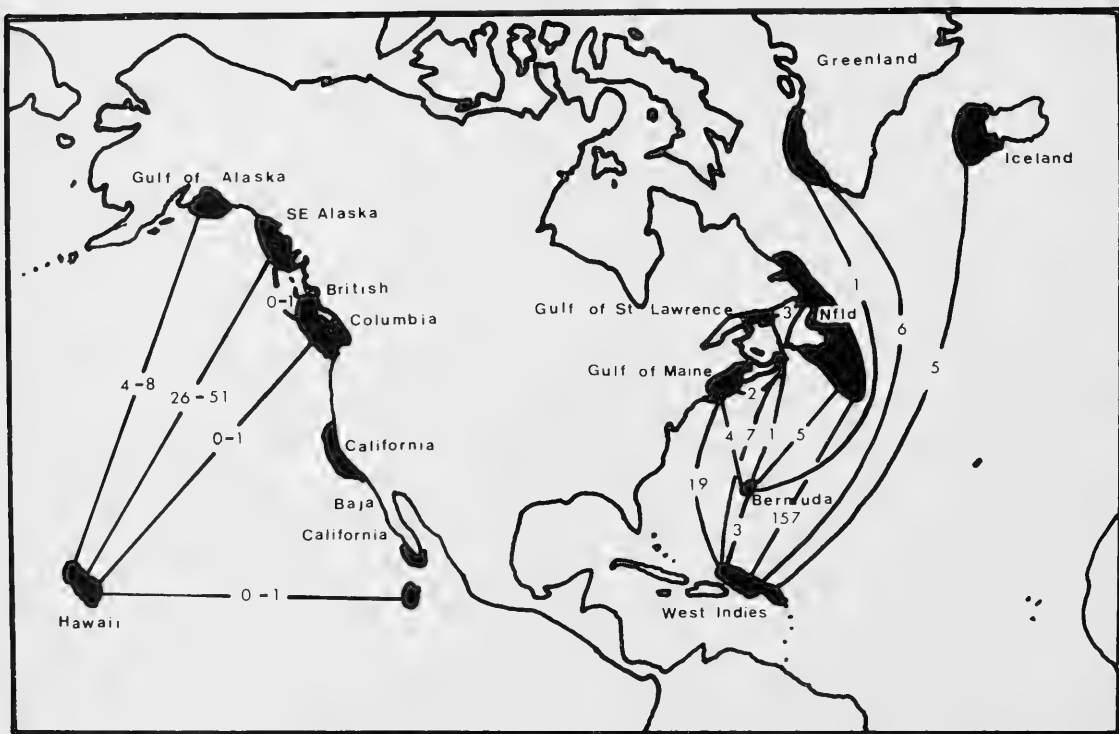


FIGURE 2. Map showing distribution and migrations of Humpback Whales in the western North Atlantic and eastern North Pacific. Lines join locations between which fluke photographs have been matched. Numbers on lines give numbers of matches. Data for the western north Atlantic is from the western north Atlantic Humpback Fluke Catalogue, as of February 1984 (J. Beard and S. Katona, personal communication). Data for the eastern north Pacific is from Baker et al. (1983), first number, and Darling and McSweeney (1983), second number. Some matches may have been made by both sets of workers. Nfld = Newfoundland.

discrete feeding populations, with little or no interchange between them (Katona et al. 1983; Darling and McSweeney 1983). The Atlantic, Iceland, west Greenland, Newfoundland-Labrador, and the Gulf of Maine areas contain separate sets of animals (although both Gulf of Maine and Newfoundland-Labrador Humpback Whales have been identified in the Gulf of St. Lawrence (J. Beard, personal communication). However, humpbacks from these different summering areas mix in the West Indies during winter and off Bermuda in spring (Katona et al. 1983). In the Pacific there appear to be discrete regional feeding areas in Alaska, with animals mixing off Hawaii in winter (Baker et al. 1983; Darling and McSweeney 1983). There is some interchange from year to year between Baja California and Hawaii (Darling and Jurasz 1983; Payne and Guinee 1983).

Protection

Humpback Whales have been protected from whaling by the International Whaling Commission in

the North Pacific since 1965, and in the North Atlantic since 1955. Forty-one Humpback Whales were taken for scientific purposes off eastern Canada between 1966 and 1971 (Mitchell 1973). Aboriginal whaling does occur both off west Greenland, where there has been a catch limit of 10 whales in recent years (11 whales taken in 1982), and off Bequia in the West Indies (where the International Whaling Commission did not have data in 1981 or 1982) but in earlier years one to five animals were caught (Anonymous 1981b).

Canada announced that it was leaving the International Whaling Commission (IWC) in 1981 with the statement: "Since the Canadian Government banned commercial whaling in 1972, Canada no longer has any interest in the whaling industry or in related activities of the IWC" (Anonymous 1981a).

The species is protected from international trade by listing on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Humpbacks were listed as

a Threatened Species in Canada by COSEWIC in 1982.

Population Size and Trends

Three principal methods have been used to estimate the population sizes of Humpback Whales in the waters off North America: cumulative catch statistics to estimate original population sizes, strip or line transects from ships or aeroplanes, and mark-recapture methods using individual-identifying fluke photographs. Each of these methods is subject to error.

Cumulative catch statistics underestimate pre-whaling populations if whaling operations under-reported their catches or were not included in the calculations.

Early strip transects, such as those of Mitchell (1973) and Winn et al. (1975), used unrealistically wide strip widths in which it was assumed that all whales were sighted. For line transects there is the problem of estimating right-angle distances to sighted whales. For all transects the proportion of time that the whales are at the surface must be estimated, the movement of the whales reckoned with, and the definition of the study area carefully considered. These sources of error generally bias strip or line transects so that they underestimate the numbers present.

For mark-recapture techniques based on individual identifications there are problems if the identifying marks change (as Carlson and Mayo (1983) have shown to be sometimes the case for western north Atlantic Humpbacks) or poor quality photographs

are included, making matching unreliable. These failings produce overestimates. The estimates of Balcomb (1983) and Katona et al. (1983), which included poor quality photography in the data base, are particularly susceptible to this type of error.

Tables 1 and 2 show Humpback Whale population estimates for the eastern north Pacific and western north Atlantic populations, or large parts of them. In cases where an author has revised estimates from a particular set of data, only the most recent estimate is given.

There is some variation in the population estimates from the eastern north Pacific. Some segments of the stock, particularly those off Baja California, have received little attention. However, the estimates suggest a population of about 2000 animals, about 13% of the estimated pre-whaling population of the entire North Pacific. The western north Pacific population is considered to be very low (Johnson and Wolman 1983).

In the western north Atlantic the estimates also show variation. A minimum estimate would seem to be the 2700 in the western north Atlantic fluke catalogue (J. Beard, personal communication). Bearing in mind that the transect estimates tend to underestimate, and the mark-recapture estimates tend to overestimate, the population appears to be about 4000, somewhat less than conservative estimates of the 1865 population. Reeves and Mitchell (1982) point out that there was considerable whaling in both the West Indies and the Gulf of St. Lawrence before 1865, and that the pre-whaling population was therefore probably considerably larger than their estimate.

TABLE 1. Population estimates of Humpback Whales in the eastern North Pacific or North Pacific. (>) = estimate considered high by author.

Authority	Year	Estimate	Area	Method
Rice (1978)	1905	15 000	N Pacific	Cumulative catch — including western N. Pacific
Rice (1978)	1965- 1974	850	N Pacific	Strip transect on feeding grounds — strip width 5400 m
Johnson and Wolman (1983)	1982	1 200	N Pacific	?
Baker et al. (1982)	1980- 1981	2 000- 5 500	NE Pacific	Mark-recapture Hawaii-Alaska (>)
J. Darling (personal communication)	1977- 1981	2 100	Hawaii	From fluke photographs (About 1000 in any year off Hawaii)

TABLE 2. Population estimates for western North Atlantic Humpbacks Whales. (<) = estimate considered conservative by cited author. (>) = estimate considered high by cited author.

Authority	Year	Estimate	Area	Method
Reeves and Mitchell (1982)	1865	4400	NW Atlantic	Cumulative catch — even larger population before whaling in West Indies and Gulf of St. Lawrence (<)
Breiwick et al. (1983)	1865	6030	NW Atlantic	Backtracking from Mitchell (1973) — assuming natural mortality 0.04; recruitment 0.03
Sergeant (1966)	1898	1500	NW Atlantic	Cumulative catch in Newfoundland area
Mitchell (1973)	1966-1969	1266	NW Atlantic	Strip transect of NW Atlantic — assumed strip width 14 800 m (>)
Winn et al. (1975)	1973	785-1157	NW Atlantic	Strip Transect of Silver and Navidad banks — assumed strip width 5560 m (<)
Balcomb and Nichols (1978)	1977	905	Silver and Navidad	Strip transect of Silver and Navidad banks — assumed strip width 7410 m
Scott and Winn (1980)	1978	2055	NW Atlantic	Strip transect of Silver and Navidad banks — assumed strip width 3750 m (<)
Balcomb et al. (1980)	1980	2000-3000	NW Atlantic	Strip transect of Silver and Navidad banks — various strip widths (<)
Whitehead (1982)	1978, 1980	2300-4100	NW Atlantic	Line transect of Silver and Navidad banks
Whitehead (1982)	1978-1980	1700-3200	NW Atlantic (except Greenland)	Sum of mark-recapture estimates for Newfoundland and Gulf of Maine
Whitehead (1982)	1978-1980	2000-6000	NW Atlantic	Mark-recapture comparing Silver bank and summer
Balcomb (1983)	1979-1982	4741-6805	NW Atlantic	Mark-recapture comparing Silver bank and summer
Katona et al. (1983)	1976-1982	8109	NW Atlantic	Mean of mark-recapture estimates comparing winter and summer for each year — assumes natural mortality 0.04. No editing of poor photographs

Thus it is only possible to say that the western north Atlantic population is less than about 80% of the pre-whaling population.

However, the concept of "pre-whaling population" must be questioned. It is unlikely that Humpback Whales ever maintained constant populations for any considerable length of time, given the natural variation in environmental conditions and food availability.

Population estimates for the feeding grounds of the western north Atlantic are roughly 1535-2720 for Newfoundland-Labrador (Whitehead 1982), 282 for west Greenland (Perkins et al. 1983), and 827 for the U.S. Continental Shelf (Winn 1982), with about 2500 wintering on Silver Bank, and 800 on Navidad (Whitehead 1982).

The population estimates for the western north Atlantic have increased since the 1960s. The majority of this increase is due to changes in census methodology, particularly away from the unrealistically wide strip widths used in the earlier surveys, and the increasing use of the overestimating mark-recapture methods. There has also been a considerable redistribution of Humpback Whales in both oceans, with populations rising dramatically in some regions and falling sharply in others (Table 3). This has meant that trends in population size are easily confused with changes in distribution.

However, reviewing the estimates in Tables 1 to 3, it seems likely that both the western north Atlantic and eastern north Pacific Humpback Whales populations are steady or increasing slightly.

Habitat

Both in summer and winter, Humpback Whales have particular habitat requirements. Thus, in some ocean areas they are very abundant, reaching densities of 1.0 per square km, whereas they may be absent from an adjacent area lacking one or more of the requirements (Whitehead and Moore 1982). Furthermore, preferred summer feeding grounds may change week by week and year by year (Bredin 1983; Lien and Whitehead 1983).

The attributes of the western north Atlantic Humpback Whales' breeding areas appear to be latitudes between 10 and 22 degrees North, sea temperatures between 24 and 28°C, protection from prevailing winds, and areas of flat sea floor between 15 and 60 m deep lying less than 30 km from deep water (Whitehead and Moore 1982). Two other factors may be important: concentrations of Humpbacks Whales may attract other Humpback Whales, and human disturbance may cause shifts to other areas (Whitehead and Moore 1982). Off Hawaii many of the same attributes are present in the Humpback Whales' wintering areas, and there is more compelling evidence for the negative effects of human interference (Herman et al. 1980).

It seems, then, that relatively small areas of tropical ocean are important to the breeding success of the Humpback Whales.

The boat and aeroplane traffic around the Hawaiian Islands, together with the attentions of over-enthusiastic whale-watchers, seem to be affecting the whales and are causing concern (Herman

TABLE 3. Recent changes in Humpback Whale abundance around the North American continent.

Area	Change	Authority
WESTERN NORTH ATLANTIC		
S. Labrador	Increase since 1980	K. Lynch (unpublished data)
E. Newfoundland	High 1977-1980; Low before 1977, after 1980	Lien and Whitehead (1983)
Grand Banks	Low 1978	Hay (1982)
N. Gulf of Maine	Recent Decrease	Payne et al. (1983)
S. Gulf of Maine	Recent Increase	Payne et al. (1983)
EASTERN NORTH PACIFIC		
Glacier Bay, Alaska	Dramatic Decrease 1978	J. H. Johnson and A. A. Wolman (unpublished data ¹)
California	Dramatic Increase since 1980	Dohl (1983)

¹1983 draft manuscript: Report of the Humpback Whale (*Megaptera novaeangliae*) under the Endangered Species Act of 1973.

et al. 1980). The U.S. National Oceanic and Atmospheric Administration has proposed the establishment of a Humpback Whale sanctuary in Hawaii (Johnson and Wolman 1983). There is very little information about the Mexican breeding grounds.

In the West Indies, the major breeding areas — Silver and Navidad Banks — are protected by their inaccessibility. However, exploratory expeditions for fish and mineral exploitation concerns are planned or have been carried out. The Dominican Republic is considering establishing a Humpback Whale sanctuary on Silver Bank, although territorial possession is disputed (Johnson and Wolman 1983).

These measures of protection for the breeding grounds would appear to be adequate for the current level of human use. However, the situation should be carefully monitored: the Humpback Whales could be severely affected by increased exploitation of either the waters off Hawaii or Silver and Navidad banks.

In summer the Humpback Whales' distributions are principally controlled by those of their prey (see Lien and Whitehead 1983). Their food includes crustacean zooplankton, especially euphausiids, herring, Clupeidae, sand lance, *Ammodytes* sp., Capelin, *Mallotus villosus*, other small fish, and squid. In Alaska the principal prey seem to be euphausiids, herring and Capelin (Bryant et al. 1981; Dolphin and McSweeney 1983). In the western north Atlantic food preferences vary with area and date. Off west Greenland Capelin and sand lance seem to be the major prey (Kapel 1979), off Cape Cod it is principally sand lance (Mayo 1982), while off Newfoundland, although Capelin are the major food, krill, herring, and squid are taken at different times (Bredin 1983; Mitchell 1973).

The habitat of the Humpback Whales in summer consists of the areas where their prey are present and available. The schooling behaviour and nutritional state of the prey will also affect their availability to Humpback Whales. Thus the principal threats to Humpback Whales in summer are those which affect their prey. Drastic changes in the distribution of Humpback Whales off Newfoundland during the late 1970s can be clearly related to the status of the Capelin stocks off the coast (Lien and Whitehead 1983). When the stocks fell dramatically in 1977 many Humpbacks moved inshore, where they frequently became entangled in fishing nets set for Cod, *Gadus morhua*.

Petrochemical exploration is taking place in several of the Humpback Whales' western north Atlantic feeding areas (off west Greenland, the Labrador coast, the Grand Banks, and Georges Bank), and on the Grand Banks there have been discoveries of commercial quantities of oil. Tyack et al. (1983) have

recently shown that migrating Grey Whales, *Eschrichtius robustus*, alter their motion in response to sounds associated with oil development. Petrochemical developments are also likely to affect the Humpback Whales' prey in ways which are hard to foresee.

Studies in Alaska have shown that humpbacks react to the noise of vessels (Baker and Herman 1983), although whether this, or fluctuations in food supply, caused their dramatic departure from Glacier Bay in 1978 is uncertain. Regulations restricting vessel traffic in Glacier Bay were established in 1978.

General Biology

Reproductive Capability

Both male and female Humpback Whales become sexually mature at about nine years of age. Earlier estimates of four to five years were based on an erroneous reading of the laminae of the ear plug (Roe 1967).

Mature females produce one young about every two years, although sometimes there is only one, or three or more, years between births. Births occur between January and April in the northern hemisphere, and gestation and lactation each last about one year.

Recruitment was about 10.3% for the Antarctic Group IV population (Chittleborough 1965) and has been estimated to be between 3.9% and 11.8% for the western north Atlantic (Whitehead 1982), but no estimates are available for the Pacific. Natural mortality rates are difficult to determine, and no reliable estimates are available.

Species Movement

Humpback Whales have very pronounced seasonal migrations. In both the eastern north Pacific and western north Atlantic, migrations of Humpback Whales between summer feeding and winter breeding areas have been demonstrated by matches of photographs of flukes. The routes which have been validated in this way are shown on the map (Figure 2).

The Humpback Whales concentrate on the breeding grounds, where densities are high from late January to early April (Baker and Herman 1981; Whitehead 1982), and in the most important feeding areas. Residence times in particular feeding areas show considerable variation depending on the prey being taken. When feeding on the sand lance, off Cape Cod, numbers of Humpback Whales are present from April to November (Mayo 1982), whereas Humpback Whales visit St. Mary's Bay, Newfoundland, for about one month per year, centered on late June when the Capelin are spawning (Lien 1980). Within a particular feeding or breeding ground, individuals

may travel more than a hundred kilometres during a season (Whitehead et al. 1982; Baker et al. 1983), or may stay resident in a particular place for weeks or months (Mayo 1982).

Behaviour/Adaptability

Humpback Whales do react to boat traffic in the short term (Baker et al. 1982), and there is evidence that extensive harassment by small boats might cause them to leave an area (Herman et al. 1980). There have been no studies of the effects of large ship traffic, or oil exploration or exploitation, on Humpback Whales.

Although Humpback Whales eat quite a wide variety of prey, and will switch food sources within a few hours (Whitehead 1981), within a particular feeding area there seems to be a preferred food at any one time. This specialization may be a reason why the Humpback Whales return year after year to a particular feeding area. It is clear that the low Capelin stocks of the late 1970s changed the Humpback Whale distribution off Newfoundland (Lien and Whitehead 1983), and there is also evidence that the Humpback Whale reproductive rate was lowered immediately after the Capelin crash in 1978 (Whitehead 1982).

Limiting Factors

The factor that has most affected Humpback Whale populations is historical whaling, which had almost destroyed all Humpback Whale populations by the 1960s when the Humpback Whale was protected. The evidence indicates that both the eastern north Pacific and western north Atlantic populations have recovered somewhat since the establishment of protection. The "aboriginal" whaling that continues at Bequia and west Greenland is at a sufficiently low level that it is unlikely, by itself, to threaten the western north Atlantic population. However, a take of over ten animals per year in west Greenland is a significant proportion of the stock of about 280 Humpback Whales which feed in the area (Perkins et al. 1983). The evidence from the fluke photographs suggests that the area would not be quickly repopulated in the event of severe depletion. Therefore, the Scientific Committee of the International Whaling Commission has repeatedly recommended that the "aboriginal" catch of Humpback Whales in Greenland be halted.

Causes of natural mortality among Humpback Whales are not clearly understood. The many parasites found in and on Humpback Whales do not appear to have any serious effect on them (Tomilin 1967; Matthews 1978). They may occasionally be caught in pack-ice (Tomilin 1967), but there are few reports of this. Many Humpback Whales (about 33% off Newfoundland and Labrador: Katona et al. 1980)

show scars on their flukes from encounters with Killer Whales, *Orcinus orca*, and two incidents of Killer Whales attacking Humpback Whales have recently been observed on the Grand Banks, although it seems unlikely that Killer Whales take any but disabled or young Humpback Whales.

While habitat loss and environmental contamination do not seem to be limiting factors for the Humpback Whale at present, they could quickly become so with accelerated development throughout the Humpback Whales' ranges. The ocean is no longer a wilderness but is increasingly being considered a resource to be managed to meet human requirements. Management priorities will generally militate against non-commercial species like Humpback Whales.

Human disturbance, principally in the form of tourist vessels and aircraft, seems to have affected the Humpback Whales off Hawaii, Alaska, and possibly Cape Cod. If Humpback Whale stocks are to reach healthy levels they must be protected from this harassment.

A number of other species of whales, seabirds, and fish use the same prey as the Humpback Whale. Mitchell (1974) has considered the interactions between Humpback, Fin, *Balaenoptera physalus*, and Minke, *B. acutorostrata*, whales off eastern Canada where these species have similar food requirements. There are some indications that the presence of one of these species may harm the feeding efficiency of the others (Whitehead 1981), but there is no evidence of serious disturbance to Humpback Whale feeding.

The most serious threats to Humpback Whales in the past few years have come from interactions with commercial fisheries. The problems can come in several forms. The most immediate occurs when a fishery is directed at the Humpback Whales' major prey and is either causing serious depletion of the stock or is changing the behaviour of the prey in such a way as to make it less available to the whales. The sudden decline of the Capelin stocks off Newfoundland in 1978 happened soon after the development of a Capelin fishery. How related these events were is disputed (Carscadden 1983), but it is clear that fisheries have the potential to cause immense harm to stocks of Humpback Whale prey, and that throughout the world's oceans major efforts are being mounted to exploit fish stocks.

The redistribution of the humpbacks off eastern Canada in the late 1970s brought about a second problem — entanglement in fishing gear. In 1980 at least 17 Humpback Whales died while entrapped in nets set for cod off Newfoundland (Lien 1981). The magnitude of this particular problem has diminished since 1980 (Lien and Whitehead 1983), but it could return, and Humpback Whale entrapments have been

taking place recently off Alaska and New England (J. Lien, personal communication).

Another way in which fisheries can threaten Humpback Whales is through the attitudes of fishermen. Fishermen whose nets are destroyed by entrapped whales (Newfoundland fishermen suffered \$2 500 000 damage due to whales, mostly Humpback Whales, in 1980 (Lien 1980)), or who perceive that whales are depleting their fish stocks can become hostile. This hostility is sometimes manifested in shooting at entrapped or free-swimming whales, petitions for the resumption of whaling, etc.

In order to avoid these interactions, particular care should be taken when managing fisheries for the Humpback Whales' prey species. Education is also an effective way of countering adverse attitudes and improving the treatment of entrapped whales (Lien et al. 1983).

Special Significance of the Species

The total world population of Humpback Whales is probably between 5000 and 10 000 animals, in about ten stocks (Johnson and Wolman 1983). Of these, the eastern north Pacific and western north Atlantic stocks are the healthiest, and together contain the majority of the world's Humpback Whales.

The Humpback Whales' behaviour has endeared them to the general public, and in many areas, including Hawaii, Alaska, Cape Cod, and Newfoundland, they are the basis of the whale-watching industry. Their breaches (leaps from the water), lobtails (thrashes of the flukes on the water surface), flipperings (slaps of the extremely long pectoral fins on the water surface), and surface feeding are particularly dramatic, and the beautiful songs of the wintering Humpback Whales have been featured on several popular recordings.

Because of their general proximity to shore, slow movement, clear markings, and interesting behaviour, Humpback Whales have attracted considerable scientific attention. They have, in many ways, become the standard species for benign, or non-lethal, whale research.

The Humpback Whale is taxonomically isolated, with no other species in its genus.

Evaluation

Western North Atlantic

The population of Humpback Whales in the western north Atlantic seems to have recovered to a substantial proportion of its pre-whaling numbers. It is in no immediate danger of extinction. However, the Humpbacks are vulnerable because of their restrictive breeding habitat requirements — Silver and Navidad banks are probably vital to them. The immediate

threat from entrapments in fishing gear off Newfoundland has receded, but there is considerable, and increasing, commercial activity in most of the major feeding areas. The effects of this activity are generally unknown. Although the population of humpbacks in the western north Atlantic is the healthiest in the world, it numbers only a few thousand animals, and should be classified as rare.

Eastern North Pacific

Information on the eastern north Pacific stock of Humpback Whales is less complete than on the western north Atlantic animals. However, there is clearer evidence of the disturbance caused by human interference, and the breeding grounds, being closer to land, are in many ways more vulnerable. This stock may number less than 2000 animals, a very small proportion of its pre-whaling level, and should be classified as threatened.

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Literature Cited

- Anonymous.** 1981a. Canada withdraws from the International Whaling Convention and Commission. Government of Canada, Department of External Affairs Communique.
- Anonymous.** 1981b. International Whaling Statistics. Volume 87. Committee of International Whaling Statistics. Sandefjord, Norway.
- Baker, C. S., and L. M. Herman.** 1981. Migration and local movement of humpback whales (*Megaptera novaeangliae*) through Hawaiian waters. *Canadian Journal of Zoology* 59: 460–469.
- Baker, C. S., and L. M. Herman.** 1983. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. Report to National Marine Fisheries Service.

- Baker, C. S., L. M. Herman, B. G. Bays, and W. F. Stifel.** 1982. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska. Report to National Marine Fisheries Service.
- Baker, C. S., L. M. Herman, W. Stifel, B. G. Bays, and A. Wolman.** 1982. [Abstract] The migratory movement of humpback whales between Hawaii and Alaska. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Balcomb, K. C.** 1983. The stocks of humpback whales in the North Atlantic Ocean. Working Paper for Protected Stocks Subcommittee of Scientific Committee, International Whaling Commission, June 1983.
- Balcomb, K. C., and G. Nichols.** 1978. Western North Atlantic humpback whales. Report of the International Whaling Commission 28: 159-164.
- Balcomb, K. C., G. Nichols, and N. J. Haenel.** 1980. Western North Atlantic humpback whale census near Hispaniola — Winter 1980. International Whaling Commission Scientific Committee Document SC/32/PS25.
- Bird, J. E.** 1983. An annotated bibliography of the published literature on the humpback whale (*Megaptera novaeangliae*) and the right whale (*Eubalaena glacialis/australis*), 1864-1980. Pages 467-628 in Communication and behavior of whales. Edited by R. S. Payne. Westview Press, Boulder, Colorado.
- Bredin, K.** 1983. [Abstract] Foraging ecology of humpback whales off Newfoundland. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Breiwick, J. M., E. Mitchell, and R. R. Reeves.** 1983. [Abstract] Simulated population trajectories for northwest Atlantic humpback whales, 1865-1980. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Bryant, P. J., G. Nichols, T. B. Bryant, and K. Miller.** 1981. Krill availability and the distribution of humpback whales in southeastern Alaska. Journal of Mammalogy 62(2): 427-430.
- Carlson, C. A., and C. A. Mayo.** 1983. [Abstract] Changes in the pigment and scar patterns on the ventral surface of the flukes of humpback whales observed in the waters of Stellwagen Bank, Massachusetts. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Carscadden, J. E.** 1983. Capelin (*Mallotus villosus*) in the northwest Atlantic. In Marine birds: feeding ecology and commercial fisheries. Edited by D. N. Nettleship, G. A. Sanger, and P. F. Springer. Canadian Wildlife Service Publication, Ottawa.
- Chittleborough, R. G.** 1965. Dynamics of two populations of the humpback whale, *Megaptera novaeangliae* (Borowski). Australian Journal of Marine and Freshwater Resources 16: 33-128.
- Darling, J. D., K. M. Gibson, and G. K. Silber.** 1983. Observations on the abundance and behavior of humpback whales (*Megaptera novaeangliae*) off West Maui, Hawaii, 1977-79. Pages 201-202 in Communication and behavior of whales. Edited by R. S. Payne. Westview Press, Boulder, Colorado.
- Darling, J. D., and C. M. Jurasz.** 1983. Migratory destinations of North Pacific humpback whales (*Megaptera novaeangliae*). Pages 359-370 in Communication and behavior of whales. Edited by R. S. Payne. Westview Press, Boulder, Colorado.
- Darling, J. D., and D. J. McSweeney.** 1983. [Abstract] Observations on the migrations of North Pacific humpback whales (*Megaptera novaeangliae*). Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Dohl, T. P.** 1983. [Abstract] Return of the humpback whale (*Megaptera novaeangliae*) to central California. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Dolphin, W. F., and D. McSweeney.** 1983. [Abstract] Aspects of the foraging strategies of humpback whales determined by hydroacoustic scans. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Hay, K.** 1985. Status of the Humpback Whale (*Megaptera novaeangliae*), in Canada. Canadian Field-Naturalist 99(3): 425-432.
- Herman, L. M., P. H. Forestell, and R. C. Antinaja.** 1980. The 1976/77 migrations of humpback whales into Hawaiian waters: composite description. Final Report to U.S. Marine Mammal Commission MMC — 77/19.
- Kapel, F. O.** 1979. Exploitation of large whales in West Greenland in the 20th century. Report of the International Whaling Commission 29: 197-214.
- Katona, S. K., K. C. Balcomb, J. A. Beard, H. Whitehead, and D. Matilla.** 1983. [Abstract] The Atlantic humpback whale catalogue. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Katona, S., P. M. Harcourt, J. S. Perkins, and S. Kraus.** 1980. Humpback whales in the western North Atlantic: a catalogue of identified individuals. Second edition. College of the Atlantic, Bar Harbor, Maine.
- Leatherwood, S., D. K. Caldwell, and H. E. Winn.** 1976. Whales, dolphins and porpoises of the western North Atlantic. A guide to their identification. NOAA Technical Report National Marine and Fisheries Service, Seattle. Circular 396.
- Leatherwood, J. S., R. R. Reeves, W. F. Perrin, and W. E. Evans.** 1982. Whales, dolphins and porpoises of the eastern North Pacific: a guide to their identification. NOAA Technical Report National Marine and Fisheries Service, Seattle. Circular 396.
- Lien, J.** 1980. Whale entrapment in inshore fishing gear in Newfoundland. Final Report to Canadian Government. Department of Fisheries and Oceans, Ottawa.
- Lien, J.** 1981. Humpback whale collisions with inshore fishing gear in Newfoundland. Canadian Atlantic Fisheries Scientific Committee Marine Mammals Meetings, Halifax, Nova Scotia, 14-16 April 1981. Working Paper 81/89.
- Lien, J., S. Staniforth, and L. Fawcett.** 1983. Teaching fishermen about whales: the role of education is a fisheries management and conservation problem. [Paper presented at National Marine Educational Association, S. Portland, Maine, August 1983.]

- Lien, J., and H. Whitehead. 1983. [Abstract] Changes in humpback (*Megaptera novaeangliae*) abundance off northeast Newfoundland related to the status of capelin (*Mallotus villosus*) stocks. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Mackintosh, N. A. 1965. The stocks of whales. Fishing News Books, London.
- Maser, C., B. R. Mate, J. F. Franklin, and C. T. Dyrness. 1981. Natural history of Oregon Coast mammals. Pacific Northwest Forest and Range Experiment Station. U.S. Department of Agriculture, Forest Service, General Technical Report. PNW-133.
- Matthews, L. H. 1978. The natural history of the whale. Columbia University Press, New York.
- Mayo, C. A. 1982 Observations of cetaceans: Cape Cod Bay and southern Stellwagen Bank, Massachusetts, 1975-1979. National Technical Information Service Report, Marine Mammal Committee — 80/07.
- Mitchell, E. 1973. Draft report on humpback whales taken under special scientific permit by eastern Canadian land stations, 1969-1971. Report of the International Whaling Commission 23: 138-154.
- Mitchell, E. D. 1974. Trophic relationships and competition for food in Northwest Atlantic whales. Proceedings of the Canadian Society of Zoologists Annual Meeting 1974: 123-133.
- Payne, R., and K. N. Guinee. 1983. Humpback whale (*Megaptera novaeangliae*) songs as indicators of stocks. Pages 333-358 in Communication and behavior of whales. Edited by R. S. Payne. Westview Press, Boulder, Colorado.
- Payne, P. M., K. D. Powers, J. R. Nicholas, and L. O'Brien. 1983. [Abstract] Apparent shift in the distribution of the humpback whale (*Megaptera novaeangliae*) in the Gulf of Maine in response to increased densities of the sand eel (*Ammodytes americanus*). Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Perkins, J. S., K. C. Balcomb, and G. Nichols. 1983. [Abstract] West Greenland humpbacks, update to 1983. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Pike, G. C., and I. B. MacAskie. 1969. Marine mammals of British Columbia. Fisheries Research Board of Canada Bulletin 171.
- Reeves, R., and E. Mitchell. 1982. How many humpbacks — then and now? The Log of Mystic Seaport 34(3): 71-83.
- Rice, D. W. 1978. The humpback whale in the North Pacific: distribution, exploitation, and numbers. In Report on a workshop on problems related to humpback whales, *Megaptera novaeangliae*, in Hawaii. Edited by K. S. Norris and R. R. Reeves. Marine Mammal Commission Report MMC — 77/03.
- Roe, S. J. 1967. Seasonal formation of laminae in the ear plug of the fin whale. Discovery 35: 1-30.
- Scott, G. P., and H. E. Winn. 1980. Comparative evaluation of aerial and shipboard sampling techniques for estimating the abundance of humpback whales. Final Report to U.S. Marine Mammal Commission, Report Number MMC — 77/24.
- Sears, R. 1983. [Abstract] Humpback whale (*Megaptera novaeangliae*) distribution and dispersal in the Gulf of St. Lawrence. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Sergeant, D. E. 1966. Populations of large whale species in the western North Atlantic with special reference to the fin whale. Fisheries Research Board of Canada Circular Number 9.
- Tomilin, A. G. 1967. Mammals of the USSR and adjacent countries. Cetacea, Volume 9. Translated from the Russian by Israel Program for Scientific Translations, Jerusalem.
- Tyack, P., C. Clark, and C. Malme. 1983. [Abstract] Migrating gray whales alter their motion in response to sounds associated with oil developments. Fifth Biennial Conference on the Biology of Marine Mammals. Boston, Massachusetts, November 1983.
- Whitehead, H. 1981. The behaviour and ecology of the humpback whale in the northwest Atlantic. Ph.D. thesis, Cambridge University.
- Whitehead, H. 1982. Populations of humpback whales in the northwest Atlantic. Report of the International Whaling Commission 32: 345-353.
- Whitehead, H., P. Harcourt, and R. Silver. 1982. The migration of the humpback whales along the northeast coast of Newfoundland. Canadian Journal of Zoology 60: 2173-2179.
- Whitehead, H., and M. J. Moore. 1982. Distribution and movements of West Indian humpback whales in winter. Canadian Journal of Zoology 60(9): 2203-2211.
- Williamson, G. R. 1961. Winter sighting of a humpback whale suckling its calf on the Grand Bank of Newfoundland. Norsk Hvalfangst-Tid 50: 335-336, 339-341.
- Winn, H. E. 1982. A characterization of marine mammals and turtles in the mid- and North-Atlantic areas of the U.S. Outer Continental Shelf. Final Report of the Cetacean and Turtle Assessment Program, for U.S. Department of the Interior, Bureau of Land Management.
- Winn, H. E., R. K. Edel, and A. G. Taruski. 1975. Population estimate of the humpback whale (*Megaptera novaeangliae*) in the West Indies by visual and acoustic techniques. Journal of the Fisheries Research Board of Canada 32: 499-506.

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Updated Status of the Right Whale, *Eubalaena glacialis*, in Canada*

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At the present time, four northern hemisphere and eleven southern hemisphere populations of Right Whales, *Eubalaena glacialis*, are recognized by the International Whaling Commission's Scientific Committee. One of the northern hemisphere stocks (eastern North Atlantic) is virtually extinct. Right Whales are only rarely observed in Canadian waters on the west coast, where a population estimated at not more than about 120 feeds in summer on the Alaskan Shelf and in the eastern Bering Sea. Animals seen in Canadian waters may represent fall to spring dispersal, but nothing is known about the migrations of this relict population. The population in eastern Canadian and United States waters is better known. Estimates range from a conservative value of about 150 to 380 ± 688 . The proven count of recognizable individuals by the five-year CeTAP survey from Cape May to Nova Scotia was 85, although the NEA research group claims to have seen more. Recognizable animals in this population have been observed to move from the vicinity of Cape Cod to the Bay of Fundy, and from Cape Cod to Browns Bank off Nova Scotia and back. Interchanges between the Bay of Fundy and Browns Bank have been recently verified. Cape Cod is most heavily frequented in the spring, the other areas in summer. The population is probably more dispersed in winter, with sightings as far south as Georgia and Florida. It has not been possible to establish whether either of these populations is stable, declining or increasing because of the problems associated with the survey of such small numbers of individuals over such wide geographical areas. The calf count, giving a minimum estimate of the Gross Annual Reproductive Rate, is unknown for the west coast, and is only about 4% for the east coast. Possible reasons for the lack of recovery of these populations are the influence of loss of inshore habitat on the east coast through human activities and possible competition with other species in the pelagic ecosystem, such as the Atlantic Herring and Sei Whale, both of which feed extensively on copepods, the primary food of the Right Whales.

Le Comité scientifique de la Commission baleinière internationale reconnaît quatre populations de la baleine noire *Eubalaena glacialis* dans l'hémisphère boréal et onze dans l'hémisphère austral. Le stock de l'Atlantique nord-est est pratiquement disparu. Dans les eaux canadiennes, la baleine noire n'est que rarement observée sur la côte ouest, où une population totalisant tout au plus 120 individus s'alimente sur la plate-forme de l'Alaska et dans la mer de Béring orientale. Les animaux observés dans les eaux canadiennes peuvent être des individus se déplaçant localement en automne et au printemps, mais on ne sait rien au sujet des migrations de cette population relique. Plus de données sont disponibles sur la population peuplant les eaux canadiennes et américaines orientales. Les estimations varient entre 150 à 380 ± 688 individus. Le levé quinquennal du Cetap, de Cape May à la Nouvelle-Ecosse, a permis d'identifier 85 individus, mais le groupe de chercheurs de la NEA prétend en avoir vu davantage. Les animaux reconnaissables de cette population vont et viennent entre les environs de Cape Cod et la baie de Fundy et entre Cape Cod et banc de Brown, au large de la Nouvelle-Ecosse. Des échanges entre les groupes de la baie de Fundy et du banc de Brown ont été récemment confirmés. Cape Cod est plus fréquenté au printemps tandis que les autres zones le sont à l'été. En hiver, la population est probablement plus dispersée car des individus ont été signalées aussi loin que la Georgie et la Floride. Vu les problèmes associés au dénombrement d'un nombre aussi petit d'individus dispersés sur une telle aire géographique, on n'a pu établir si l'une ou l'autre de ces populations était stable, baissait ou augmentait. Le nombre de baleineaux, qui génère une estimation minimum du taux annuel brut de reproduction, s'élève seulement à environ 4% sur la côte est, et reste inconnu sur la côte ouest. Les raisons possibles de l'absence d'un rétablissement de ces populations sont l'influence de la perte d'habitats sur la côte est à cause d'activités humaines, et la compétition possible avec l'Atlantique et le rorqual boréal qui mangent tous deux beaucoup de copépodes, principal aliment de la baleine noire.

Key Words: Baleen whale, Right Whale, *Eubalaena glacialis*, endangered, whaling.

The Right Whale, *Eubalaena glacialis*, which is represented by two segregated populations (*E. g. japonica* and *E. g. glacialis*) in the North Pacific and North Atlantic, respectively, and a third stock (*E. g. australis*) in the southern hemisphere, was hunted to

the verge of total extinction by whalers of the 15–19th centuries. The species is seasonally migratory in habit in all the oceans, but while it is associated with relatively cool waters in the northern hemisphere temperate zone in summer, it now rarely penetrates the higher latitudes inhabited by its relative the Bowhead Whale, *Balaena mysticetus*. Right Whales disperse into the lower temperate and upper subtropical latitudes in the winter months but rarely occur in any numbers in the tropics (Figure 1).

*Endangered status originally assigned by COSEWIC April 1980 (see Hay 1985). Endangered status reaffirmed April 1985.



FIGURE 1. Mating behaviour of Right Whales in the western Bay of Fundy, August 1982 (photo: L. White).

Distribution

North Pacific: The present distribution in the eastern (and western) North Pacific is undoubtedly less extensive than in pre-whaling years. Data assembled by Nemoto (1957, 1959 and 1962) and in various progress reports by Japan to the International Whaling Commission (summarized by Gaskin 1976) were largely collected from pelagic whaling or whale research vessels in the summer months and have a strong bias towards the May-September period. Nevertheless, they reveal that most of the remaining North Pacific Right Whales congregate in summer on the southeastern shelf of the Bering Sea, around the eastern Aleutian Islands, and Kodiak Island (Figure 2). Some animals occasionally penetrate the northern Bering Sea in mid-summer, and there are one or two relatively recent records from the Chukchi Sea. The species in effect occupies during the summer what in winter is essentially the southern part of Bowhead Whale range in the region. During the summer, most of the Bering Sea population of the latter species is

spread out between the north shelf of Alaska and Amundsen Gulf, so actual overlap is minimal. The wintering grounds of the North Pacific Right Whale are poorly known although there are scattered reports of animals seen off British Columbia, northern Oregon and Hawaii, the original winter range was much more extensive, reaching southern Oregon and possibly California as well.

The virtual extirpation of the species in the western North Pacific resulted from traditional whaling around Japan and Korea (Right Whales can clearly be identified in a number of old whaling prints of Japanese origin) and by American and European whalers operating on both sides of the North Pacific and northwards into the Bering Sea. Some Right Whales were taken by whalers on their way to and from the Chukchi and Beaufort seas in search of Bowhead Whales.

North Atlantic: The hunting activities which culminated in the near-extinction of Right Whales in all regions of the North Atlantic originated in Europe.

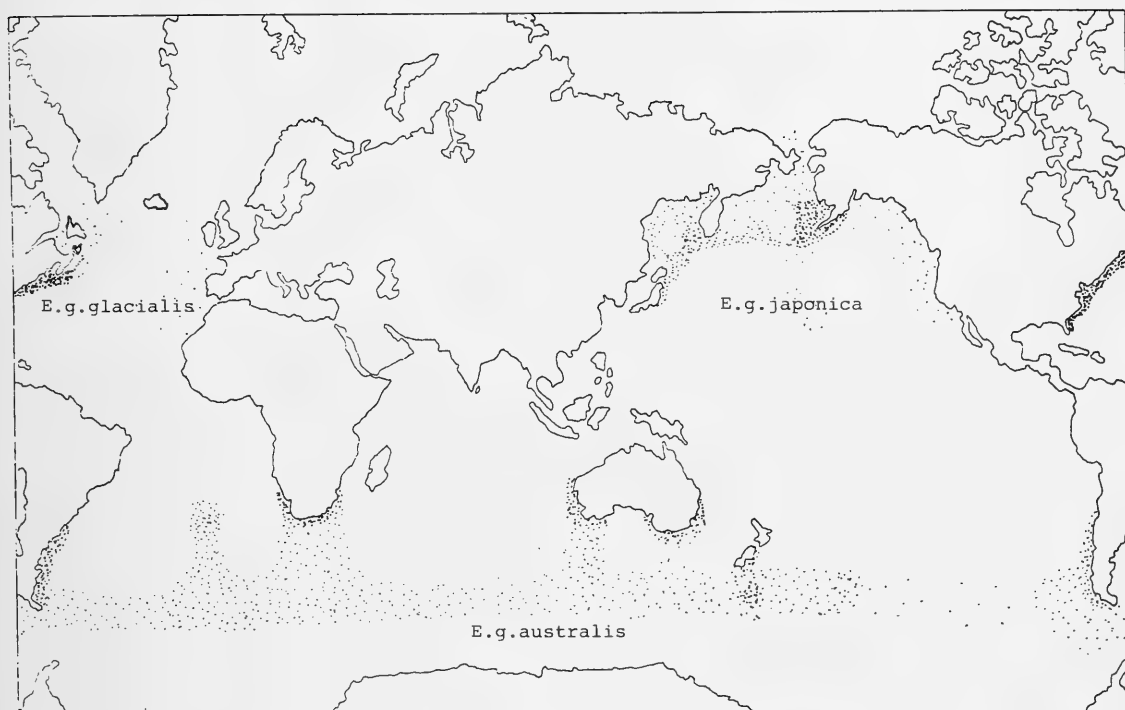


FIGURE 2. Approximate distributions of the three subspecies of *Eubalaena glacialis* at the present time.

The Basques began whaling for this species in the late 15th-early 16th centuries and within 100 to 150 years the diminishing size of stocks in the Bay of Biscay and adjacent areas led them to search first for Right Whales, then for Greenland Right Whales (European Bowhead) northwards to Norway and Spitsbergen, northwest to Iceland, Greenland and Newfoundland-Labrador, and south to West Africa.

The power of Britain, Holland and France expanded rapidly during the 16th-18th centuries, and the maritime strength of the Basque country dwindled into obscurity. No more Right Whales visited the Cantabrian Sea, however, and this eastern population must be considered virtually extinct. A bare handful of sightings have been made in the last three decades; some of these may be strays from the western North Atlantic.

Whaling by North American colonists from land bases, together with the activities of the embryonic pelagic fleet of the 18th century (later to metamorphose into the Yankee Sperm whaling [*Physeter catodon*] industry) maintained pressure on the western North Atlantic stocks. Nevertheless, this population has survived (unlike its eastern counterpart), although it is numerically still probably the

rarest large baleen whale regularly occurring in Canadian waters. At most, the population size of the North Atlantic Right Whale is barely 10% of the combined eastern and western Arctic stocks of Bowhead Whales.

This population has been the subject of several studies during the last three to four years, and its distribution and movements are reasonably well-known, at least in broad outline (Figures 3 and 4). During the winter months the population seems to be dispersed, with some out on the continental shelf, some reaching Bermuda (rarely), and others remaining inshore and wandering as far south as Georgia and Florida. From April onwards, numbers begin to build up in the vicinity of Cape Cod and its adjacent system of banks and offshore ledges. Later in the spring a northward movement begins (or continues), which sees a major portion of the population move into the Gulf of St. Lawrence and on the shores and banks of Newfoundland. In the last decade a few sightings from these areas indicate that these regions are still within the summer range of some members of the population. The range extended to Davis Strait and southern Greenland in pre-whaling days (Allen 1908); in the work of Mitchell (1974)

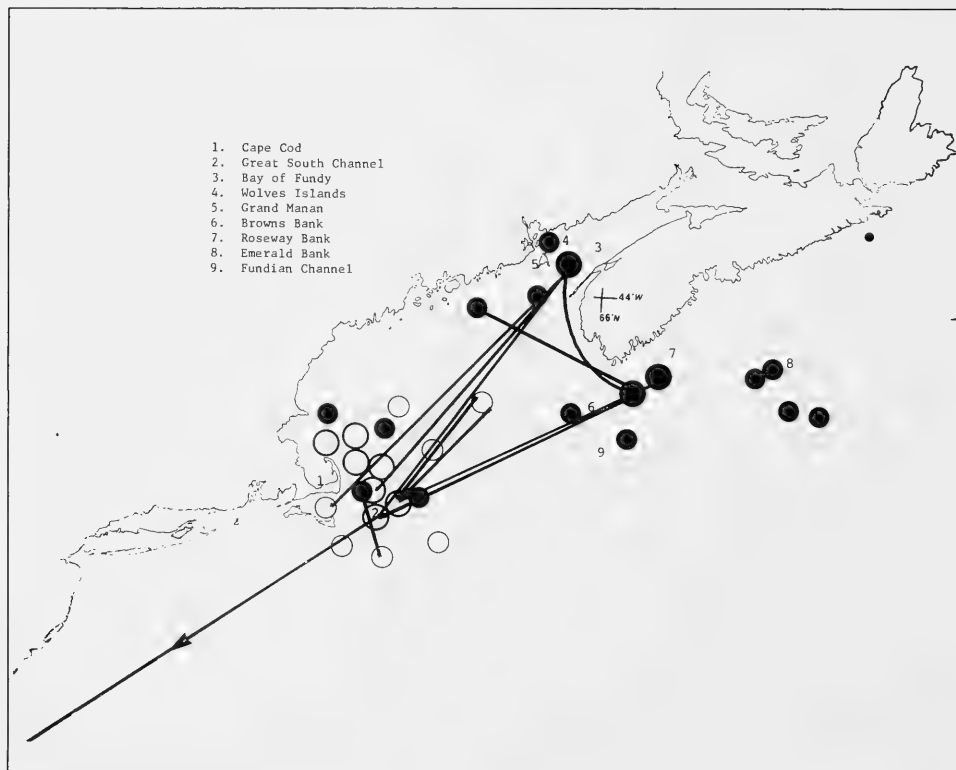


FIGURE 3. Spring (open circles) and summer (closed circles) distributions and known interchanges (lines) based on recognizable individual Right Whales in the northwest Atlantic. Based on CeTAP, NEA, University of Guelph and Blandford whaling station data.

and Reeves et al. (1978), there is a suspicion that a recolonization of all former range is under way. Alternatively, the pessimistic view is that some animals are being forced to disperse more widely to search out new calving and nursing grounds, or feeding areas, as human disturbance by vessel traffic and associated noise reduces the quality of the areas presently used by the species. There is no doubt that far more people are looking for whales than a decade ago; the increased reports are in part, at least, a function of that increase in observers and do not necessarily reflect a real increase in whale numbers unless we can find some way to quantify the effort.

From the Canadian point of view, at the present time rather regular concentrations of a few tens of animals occur in summer-fall in the southern Bay of Fundy (usually to the east of Grand Manan Island, but sometimes extending as far north as the Wolves Islands) and on the continental shelf of the Atlantic coast of Nova Scotia in the relatively deep water between Browns Bank and Roseway Bank. They may

also be found west and south of the Emerald Bank and in the mouth of the Fundian Channel, but in smaller numbers (Blandford Whaling Company data for 1970-72; Sutcliffe and Brodie 1977).

Protection

At the present time all Right Whale populations are, in theory, totally protected by signatory nations of the International Whaling Commission (IWC) and have been since the Convention was originally signed in Washington on 2 December 1946, or at least when the individual nations ratified the document. A measure of *de facto* protection actually existed during the 1930s in pelagic waters, and certainly after the International Whaling Agreement was drawn up in 1937. Land stations, however, continued to take Right Whales as and when they became available: Brazil, which joined the Convention in 1947 but did not actually send a commissioner or take part until 1973 (observer sent), took at least six Right Whales in the post-protection period and possibly far more. The

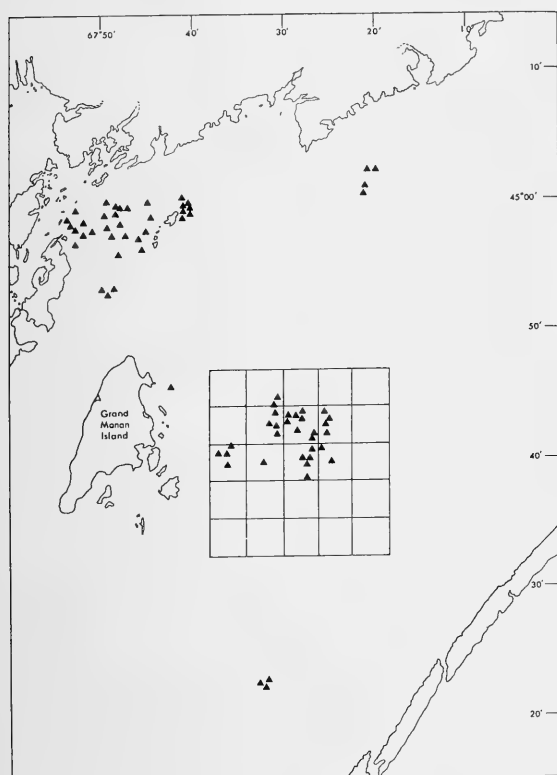


FIGURE 4. Sightings of Right Whales in the Bay of Fundy during summer 1980; data from NEA Reports.

history of this exploitation is being investigated by the IWC at the present time. Chile reported six taken in 1955 and one in 1959; in the North Pacific a few were taken by Japan, the USSR and Canada (one) during the 1950s (see Omura 1958; Klumov 1962). Reeves et al. (1978) summarized the small number taken in earlier years (end of 19th century and beginning of the 20th) on the eastern seaboard of the United States. One factory ship of the USSR is known to have violated the Convention by killing an unspecified number of Right Whales around Tristan de Cunha in 1958. Apart from these lapses, the protective measures appear to have been successful inasmuch as some remnants have persisted into the 1980s in all oceans previously occupied.

In addition, the species is listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). Canadian whaling regulations under the Fisheries Act also prohibit the taking of whales in Canadian waters.

Population Sizes and Trends

The current status of global populations of Right Whales was reviewed and discussed at a symposium and workshop meeting sponsored by the IWC and held in Boston from 15 to 23 June 1983. There was common agreement on two points: *i*) the difficulty of accurately counting small populations of whales dispersed over wide geographical areas, and *ii*) the greater difficulty of establishing any population dynamic or demographic trends even in more or less genetically isolated sub-stocks. There are data (Kraus and Prescott 1983; Winn et al. 1983) showing local movements of individual Right Whales over some hundreds of kilometers within a population spatial range, but no evidence for movements between populations. The 1983 working group recognized four discrete northern hemisphere stocks (NE and NW Pacific and Atlantic, as already indicated in this paper), and up to eleven southern hemisphere groups (Chilean, New Zealand, Campbell Island, SE African, Greenwich (= SW African), Tristan/Pigeon Islands, and groups I and II (= Argentinian and Brazilian) in the SW Atlantic.

In the Pacific, only the NE Pacific stock is of specific interest to North America; numbers are low. Ohsumi and Wada (1974) and Wada (1976) applied effort corrections to Japanese pelagic sighting data collected in the late 1960s and early 1970s in the eastern North Pacific and the Bering Sea and concluded that the best estimate of mean population size was about 120, with no evidence for any population trends.

Recent data on the western North Atlantic population have been collected by a number of groups (Watkins and Shelvill 1982; Winn 1982; Winn et al. 1983; Kraus and Prescott 1981, 1982, 1983; Murison and Gaskin 1983, unpublished data). Winn et al. (1983) reported on the cumulative survey data collected during the Cetacean and Turtle Assessment Program (CeTAP) between 1979 and 1982. The peak average abundance from Cape Hatteras to the Bay of Fundy, adjusted for diving behaviour, was 380 ± 688 . The large variance of this estimate can be improved at the lower level by correcting for the minimum number of recognizable individuals charted during the program from about 5000+ photographs of callosity pattern or body marks and scars, i.e. 85 animals. Kraus and Prescott (1983) reported that their work since 1980 had yielded photographic identifications of over 200 Right Whales in this region. Because of the instability in callosity patterns from year to year in some animals (Watkins and Schevill 1982) and the author's experience with such photographic interpretations, it is preferable to regard this as a high estimate. Winn et al. (1983) considered that a safer

estimate for purposes of estimating population trends was a maximum of 150.

Sightings of Right Whales are coming from many individuals and conservation organizations at the present time and the total is quite high each year. There is no doubt, however, that many of these are redundant and represent the same few animals moving from place to place and being re-sighted. Accessible pods of Right Whales were originally found by Watkins and Schevill (1982) off Cape Cod in the mid-1950s and later in the Bay of Fundy. More were located as a result of survey work carried out by the New England Aquarium as part of the assessment program in regard to the application by the Pittston Company to situate an oil refinery and tanker terminal at Eastport, Maine.

Despite the greatly increased input of sightings of *E. glacialis* there is no evidence of a significant increase in numbers since these observations began. This statement is not meant to preclude the possibility of an increase, but to indicate that sighting effort data were only collected in 1970-72 by the Blandford whaling operation (and they were largely interested in whales which could be taken commercially), and by CeTAP and the New England Aquarium (NEA) in 1978-83, and the University of Guelph in 1981-83. The latter two groups recognized the difficulty of estimating accurate sighting densities with a species which was a) significantly clumped in distribution and b) could spend up to 15 minutes below the surface during a feeding dive.

CeTAP and the NEA paid particular attention to collecting sightings of cow-calf pairs as accurately as possible, along with individual recognition marks or patterns. Kraus and his colleagues (1983) reported that they had sighted only 21 cow-calf pairs in four years of surveys across the Bay of Fundy and upper part of the Gulf of Maine. Since the 1970-72 sightings of the whale catcher from Blandford between Browns Bank and Emerald Bank totalled well over 400, yet included only one calf, there is no reason to believe that calves are to be found in offshore waters.

If the Gross Annual Reproductive Rate (GARR) is barely 9%, and the Net is certain to be much less, then it would take well over a decade of observations before any significant population trend might be observed that exceeded the variance in sighting data. Unless some new source of mortality becomes manifest, it may be safe to assume, for the purposes of short-term management, that the population is relatively stable as long as the number of calves seen does not fall below the current level. A GARR of that value, with the observed calf-count, should be able to sustain the observed population mean size. It would not be safe, however, to assume either a) that increase

was probably occurring, or b) that this state of affairs would continue indefinitely.

Mitchell (1975) speculated that one factor limiting the recovery of Right Whales might be competition with Sei Whales, *Balaenoptera borealis*. Competition factors were discussed at some length by Gaskin (1982) with respect to general evolution of trophic systems and the role which cetaceans play in these hierarchies. The report of the workshop held at Boston in 1983 (International Whaling Commission 1983) noted that it was of interest that while there was considerable overlap in the feeding ground of the two species on the Scotian Shelf and in the southern hemisphere, Sei Whales did not appear to have ranges coincident with Right Whales in the Bay of Fundy and on Browns Bank.

On the other hand, Watkins and Schevill (1979) observed both species feeding within a very limited area off Cape Cod in 1975-76. In fact, on one occasion, one animal of each species were swimming so close together that they were almost touching, so direct competition for dense patches of zooplankton is a distinct possibility in these circumstances. Nevertheless, copepods in the 2-3 mm size classes are abundant in enough parts of the coastal shelf region of southern New England and eastern Canada that it seems most unlikely that food supply alone is likely to be the major factor limiting population recovery.

Habitat

The overall distribution of Right Whales in the waters of Atlantic Canada and the adjacent waters of the United States is shown in Figure 3. Within this region, the CeTAP survey (Winn 1982; Winn et al. 1983) recorded the species over depths of 2 m to 377 m, and in surface water temperatures of 4.0°-18.0°C, with respective means of 140 m and 9.4°C. During late July-early September 1983, the University of Guelph workers recorded animals in waters of about 150-240 m, and in surface temperatures of 10.3°-14.5°C, with respective means of about 200 m and 12.7°C. The later value was statistically indistinguishable from the mean for 25 oceanographic stations across the middle of the Bay of 12.64°C. Water deeper than 280 m is not present in the Bay of Fundy and the upper Gulf of Maine, and only in one or two areas, specifically the Grand Manan Basin and the Jordan Basin, does it reach depths much in excess of 150 m.

A major change in the behaviour and distribution of Right Whales in the Bay of Fundy was recorded in 1983 in comparison with 1980-82; there was some consideration given to the idea that sea temperature changes might have been directly or indirectly involved, specifically with lower values occurring in

the outer bay in 1983 than in 1980-82. Kraus and Prescott (1982: Figure 11) gave 1981 August and September surface temperatures for the region derived from bathythermograph readings, obtaining a range of 13.5°–16.0°C. Research vessels of the Department of Fisheries and Oceans, Canada, however, collected data in the same region in August and found a range of only 10.8°–14.4°C. While these data were admittedly taken only during the first half of the month, the difference is great enough to question the exact calibration of the equipment used by Kraus and Prescott.

The peak distribution of Right Whales, and hence the apparent summer habitat range in the Bay of Fundy approaches, is shown for each year of the period 1980-83 in Figures 4 to 7. The total sightings are replotted with respect to bathymetry in Figure 8, and in Figure 9, with reference to the transition zone between thermally stratified and well-mixed waters, calculated from the Simpson/Hunter equation BH/U^3 (where B is the buoyancy flux due to solar warming, H is the mean water depth and U the amplitude of the tidal current) (see Garrett et al. 1978) and application of the average rate of tidal dissipation D (Greenberg 1978). The contours, which were plotted using $\log(H/D) = 1.9$, correspond to a fairly abrupt transition from well-mixed to stratified. Smith et al. (1981) applied the same calculations to data obtained from the passages and channels between Deer Island and Campobello Islands, New Brunswick, and found close correlation of dense plankton with the transition zone, which would be marked by small-scale frontal discontinuities along which horizontal convergence effects trap and concentrate flotsam, zooplankton and small nektonic organisms.

The biological importance of such anomalistic features was pointed out by Hamner and Hauri (1977), and it seems very likely that the Ot transition zone shown to the east of Grand Manan by Garrett et al. (1978) is a very important component of Right Whale feeding habitat in the Bay of Fundy region. Nor is it likely to be just coincidence that the other major areas of transition plotted by those authors in the greater Gulf of Maine region lie across the Right Whale grounds southeast of Nova Scotia. Any shift or breakdown of these zones, as a result of changes in watermass volume in the Nova Scotia Current for example, could conceivably lead to a sharp reduction in the density of available zooplankton normally concentrated at a given location, possibly to a degree that the area in question would become uneconomic for exploitation by filter-feeding animals such as Right Whales.

Other factors that might be taken into consideration in attempting to define habitat for this species

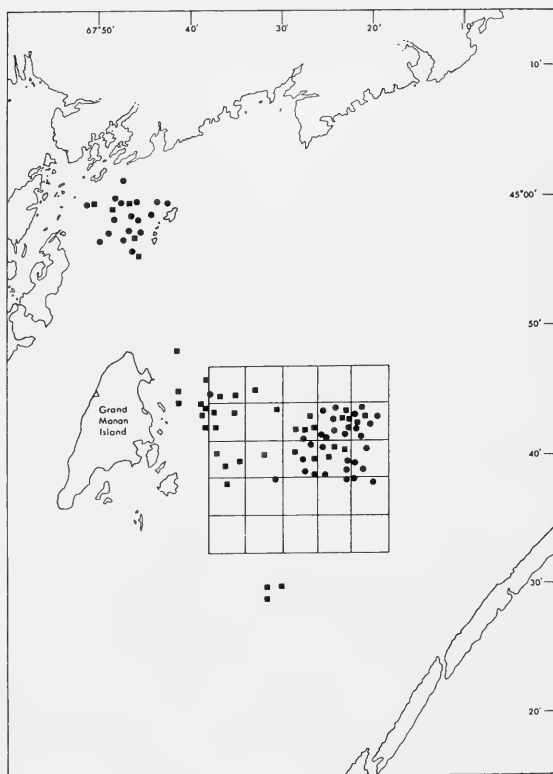


FIGURE 5. Sightings of Right Whales in the Bay of Fundy during summer 1981; data from NEA Report and Ocean Search Ltd. NEA data closed circles.

include absolute temperature itself, but the hypodermal layer of the Right Whale is so thick (20+ cm), and the surface to volume ratio so favourable because of the squat body shape, that it seems most unlikely that temperature *per se* could be important within the range observed in the Bay in summer-fall. Brodie (1981) estimated heat loss for the Bowhead Whale in Arctic waters and concluded that this animal, with morphology and blubber thickness similar to the Right Whale's, had no problem maintaining thermal neutrality in waters of only a few degrees centigrade. Salinity might be of some importance in determining buoyancy of copepod life cycle stages; the adults are probably capable of making the necessary osmotic adjustments to the limited short-term changes they might encounter in a transition zone. Components such as dissolved oxygen and carbon dioxide, nitrate, phosphate and trace elements are more likely to exert an influence on the primary production rather than on primary consumers, and are certainly not likely to directly affect an upper trophic mammal.

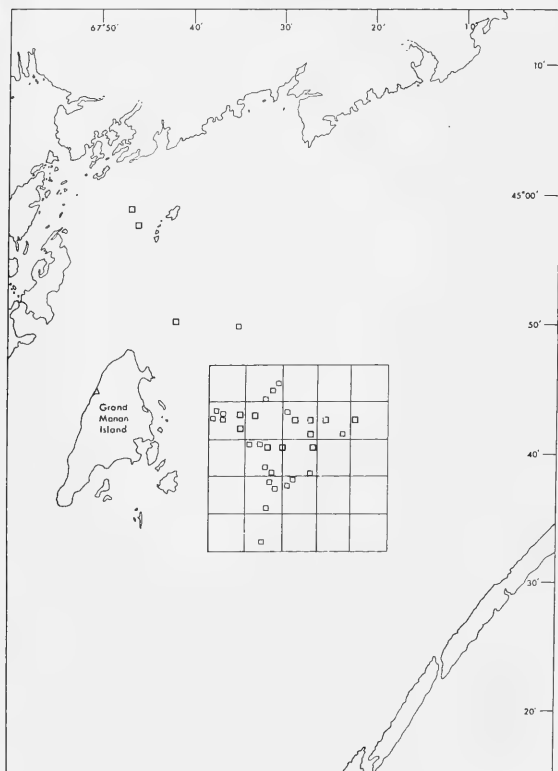


FIGURE 6. Sightings of Right Whales in the Bay of Fundy during summer 1982; data from Ocean Search Ltd. (NEA data not available.)

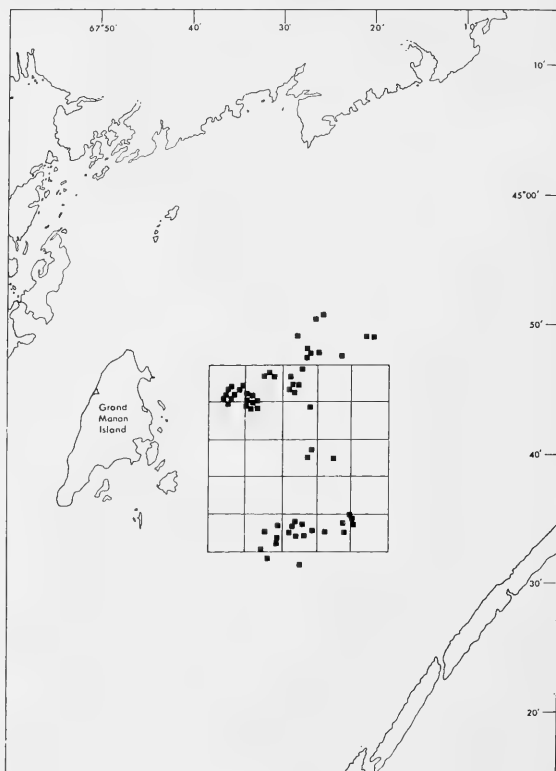


FIGURE 7. Sightings of Right Whales in the Bay of Fundy during summer 1983; data from Ocean Search Ltd. and University of Guelph research cruises. (NEA data not available.)

The problem of attempting to define reproductive habitat for the population remains. Payne (1981) noted that although mating behaviour and intromission were frequently observed at Peninsula Valdes, Argentina, in inshore waters, analysis of occupancy by individual females and studies of calf-body lengths suggested that these matings are not in fact productive; other mating behaviours which did lead to conception were assumed to take place elsewhere. The only alternative, of course, is to suggest that this species, like many pinnipeds, has delayed implantation or that gestation exceeds one year, which is also doubtful and not known to occur in any other baleen whale so far studied. The situation in the Bay of Fundy is discussed more fully in the next section on biology and reproduction.

At the present time it seems reasonable to assume that feeding is one of, if not the only, reason for the Right Whales' of the eastern seaboard congregation in the areas in which they consistently occur. They are adjacent to thermally stratified regions in each area,

so that if it is advantageous to have relatively calm or relatively less turbulent water in which to carry out mating behaviour, it is close at hand. Nevertheless, it is hard to believe that the animals could be directly affected so easily, considering their natural buoyancy. Watkins and Schevill (1979, 1982) noted the correspondence of distribution of Right Whales in the Cape Cod region with zones of high zooplankton (specifically *Calanus*) densities; Winn et al. (1983) reported that the highest concentration of *C. finmarchicus* ever recorded in the literature was collected among aggregations of Right Whales in the Great South Channel off Cape Cod. University of Guelph researchers are currently examining the distribution and density of *Calanus finmarchicus* and other calanoid copepods in the Right Whale zone of occupation in the Bay of Fundy. A total of 396 vertical hauls were made over 25 stations in July–September 1983, but these were still being analysed at the time of writing. Preliminary indications, however, are of a striking relationship between apparent long feeding

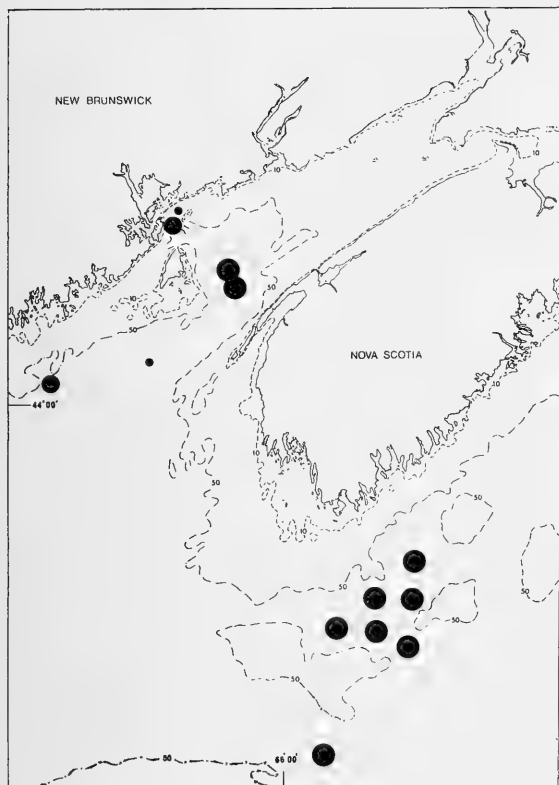


FIGURE 8. Distribution of Right Whales with respect to bathymetry. Almost all sightings have been made between 100 and 400 m.

dives and high densities of calanoids in at least one section of the vertical water column.

Habitat Protection: No protection measures are applicable to Right Whale habitat on either coast of the United States or Canada; only the animals themselves are protected from hunting and to some degree, especially in the United States, from harassment. The latter is difficult to define, the regulations difficult to enforce, and the officers required to do so are frequently unavailable because of the pressure of duties related to commercial fishing problems. Even the concept of whale "habitat" is a relatively new one to most management authorities in charge of regulating marine systems, except in the case of very clear-cut examples, such as the breeding lagoons of the Californian Gray Whale, *Eschrichtius robustus*.

Degree of Specialization and Consequent Vulnerability: The "bottom line" for the Right Whale is the availability of dense, or moderately dense, concentra-

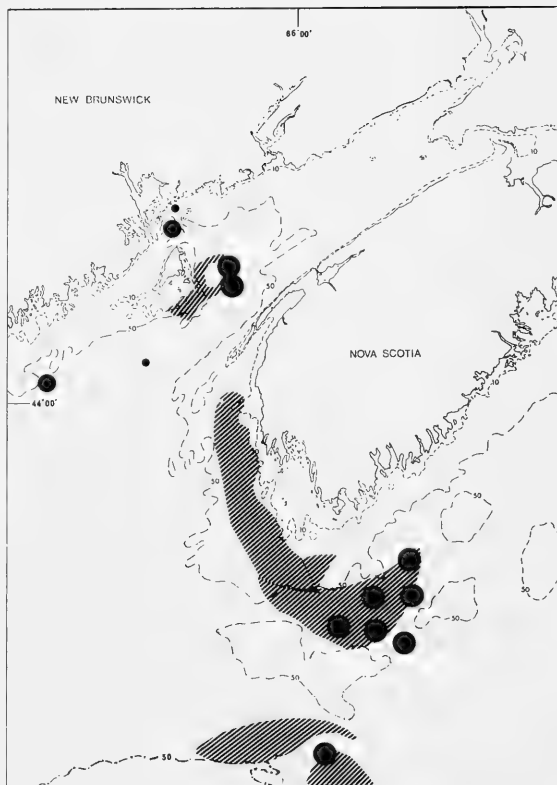


FIGURE 9. Distributions of Right Whales with respect to the transition zone between the well-mixed and thermally stratified zones in the Bay of Fundy and Gulf of Maine during summer months. Only areas where the S.H. parameter is between 1.5 and 2.5 are plotted (see Garrett et al. 1978).

tions of calanoid copepods. We have little information on the suitability of other foods, although in the southern hemisphere *Euphausia superba* and *Munida gregaria* are eaten (Matthews 1932, 1938). This may in fact only apply to a few areas such as the Patagonian Shelf, the vicinity of Campbell Island, and South Georgia. Kawamura (1978), who plotted the distribution of Right Whale catches in the southern hemisphere and related the pattern to the distributions of the major crustacean species in the pelagic ecosystem of the region, provided a good case for suggesting that *Calanus tonsus*, *C. simillimus*, *Clausocalanus laticeps*, *Parathemisto gaudichaudii* and *Euphausia vallentini* might in fact be the major food for most of the population. *Calanus plumchrus*, *C. crissatus*, *E. pacifica* and *Metridia* sp. are known foods in the North Pacific (Omura 1958; Omura et al. 1969; Klumov 1962).

It would seem, however, that the Right Whale, when alternative options are available, is probably a facultative feeder on calanoid copepods. It can no doubt satisfy its energetic requirements from other foods if the need arises. Or can it? Euphausiids shoal in such a concentrated fashion that the sieve-feeding of the Right Whale and the Sei Whale is not really competitive with the gulp-feeding of the Fin (*Balaenoptera physalus*) and Humpback whales (*Megaptera novaeangliae*), and in some areas, the Blue Whale (*Balaenoptera musculus*). In the Bay of Fundy, Fin and Humpback whales appear to congregate quite rapidly in areas where euphausiids (and herring or other pelagic shoaling fish) are aggregating. Watkins and Schevill (1979) noted the same phenomenon in the Cape Cod region. The slow-moving Right Whale may not be well equipped to deal with both a relatively agile prey and competition from fast-swimming, gulp-feeding Fin Whales. While copepods can also occur in dense concentrations, this seems to be a phenomenon rarer than shoaling by euphausiids. Only the younger Fin Whales have baleen fringes fine enough and closely spaced enough to permit them to economically exploit prey of such small particle size as *Calanus* species, so that if the Right Whale has evolved largely to feed on the latter, it does not really face competition from Fin Whales, and as indicated above, some other factors appear to control functional overlap between Right and Sei whale populations, at least in some regions.

Copepods are very abundant on the coastal shelf regions of northwestern and northeastern North America. Possibly a serious competitor of the Right Whales in the Gulf of Maine–Bay of Fundy region is the Atlantic Herring, *Clupea harengus*, which, in good years, enters the region in huge schools or banks of sufficient biomass that they must exert rather intense feeding pressure on copepods, at least in their immediate area. It is hard to see, however, given the relatively rapid growth and short generation time in the lower temperature latitudes, that availability of copepods could become a serious limiting factor to population expansion until there were far more Right Whales than there are now.

This factor in the habitat is probably not at risk. More likely is the effect (International Whaling Commission 1983) of changes in coastal land use, increases in human population around bays previously used by the species, and increases in disturbance by vessel traffic (risk of direct collision and "acoustic pollution"). Toxic waste discharge may have an influence in certain areas. We simply do not know whether this species, like the Gray Whale, has a critical need for shallow water habitat at some stage of

its annual cycle (Gaskin 1982: 346–347) or can prosper even if such habitat is denied to it.

At the present time the major impact on the Right Whale in Canadian waters is likely to be man-related, either from changes in the Fundy–Gulf of Maine region as listed above, or through persistent low-level or medium-level harassment (albeit probably unintentional) that brings about important modifications or distortions of behaviour. It is comforting to know that, in addition to the Cape Cod and Fundy coastal areas, the animal also utilizes the outer coastal shelf of Atlantic Nova Scotia where it may be less vulnerable to human interference.

In the inshore region, growing industrialization, increased large vessel traffic (often carrying hazardous cargoes), and effluent and dumped fuel and urban waste, as well as potentially toxic chemicals from the agricultural and forestry industries, may be bringing about slow but steady degradation of the pelagic habitat. It is important to realize that the current circulation of the Bay of Fundy and the Gulf of Maine are both semi-closed for part of the year, so that contaminant gradients can be established from the inshore to offshore regions. At the present time, organochlorine hydrocarbon levels are relatively high, but heavy metals (Pb, Hg, Cd), while significant, are not abnormally elevated (Gaskin 1982; Showell 1984).

Biology

In all studies of the basic biology of Right Whale populations we are confronted with the dearth of information concerning even the most basic life cycle parameters. It is quite undesirable to take animals for study from these small relict groups.

Reproductive Biology: The size at birth has been estimated as 4.5+ m in the North Atlantic (Kraus and Prescott 1982), 5.5 m in the southwest Atlantic (Whitehead and Payne 1981), 6.0 m off South Africa (Best 1981), and 6.0 m in the northwest Pacific (Ohsumi 1981). Because of apparent differences in individual juvenile growth rates and the problems associated with accurately measuring body lengths at sea on all occasions, it is difficult to assign a year-class to animals of greater size, even though Kraus' workers considered animals 8.5–9.8 m in the Bay of Fundy to be in their second year. Young of the year in the same area were 6.1–7.3 m in length, and extrapolative regression analysis by Kraus and Prescott (1981, 1982) suggested that these animals were 3–8 months old, with a birth season spread from December to April. Klumov (1962) concluded that the Right Whales in the Sea of Okhotsk–NW Pacific birthed from December to January, but this conclusion was based on a small sample size.

The estimated body length at sexual maturity is not well known in most populations. Whitehead and Payne (1981) concluded that it lay within the range of 12.5–13.5 m in the southwest Atlantic, compared with 13.5–15.5 m in the northwest Pacific (Klumov 1962; Omura et al. 1969). These lengths cannot be accurately related to absolute age at present. Analyses of the Argentinian component of the southwest Atlantic population indicated that sexual maturity could occur from 2.5–6 years of age, but these theoretical calculations were not supported by the field data. Sexual maturity in this population and in other Right Whales, therefore, is probably at 6 years of age or later.

The breeding cycle, judged from data collected off Argentina, has an average length of 3.26 years. This value includes the implicit assumption that no females calved outside the Peninsula Valdes area, nor aborted or lost calves to predation or perinatal complications (International Whaling Commission 1983). One observation of a recognizable female with a calving interval of three years was reported from the Bay of Fundy (document SC 35/RW/27, *cited in* reference above, not seen). That some neonate and calf mortality occurs, even if not commonly, is supported by records of stranded animals in several parts of the world, including the eastern seaboard of North America (Kraus and Prescott 1982). While some twinning is known to occur in baleen whales, there are no recent data for this species. The litter size in all cetaceans is normally one, and it seems likely that only one would survive if two or more were born, given the capacity of the mother to feed them and still maintain her own metabolic requirements. There is no evidence to suggest that the sex ratio deviates significantly from 1:1 either at birth or in the adult population.

The species is a social breeder. Not only do animals congregate for mating in groups, in both inshore shallow water and in deep water mating areas, but several males will cluster around a female during courtship. One male may support the female while another male copulates with her; this has been referred to as a "triad" system. Mating appears to be quite promiscuous. The fact that this species, like the Gray Whale, congregates in small areas for mating, should maximize the probability of contact and hence maximize the reproductive potential also. This makes it all the more puzzling that there has not been a similar recovery in numbers, and strongly suggests that some other factor or factors are at play also.

The problem of the apparent low reproductive rate has been alluded to in earlier sections. The Right Whale workshop was provided with a theoretical framework of Gross Annual Reproductive Rates taking the possible variation of several parameters

into account. The observation work of Kraus and Prescott suggested that a minimum value for the GARR in the northwest Atlantic was 5% (i.e. total number of first year calves as a proportion of the total population) or 0.050. In producing the theoretical matrix for survival rates and possible GARR values, J. Breiwick at the I.W.C. Workshop in 1983 assumed: *i*) a mean calving interval of 3.2 years (crude birth rate of 0.31); *ii*) female age at first birth of 11 (sexual maturity at age 10); *iii*) death rate of 4%/annum in adults, i.e. a survival rate of 0.96.; and *iv*) equal sex ratio.

The result of the balanced equation calculations yielded best estimates for GARR ranging from 0.07 to 0.09 (7–9%). Of course this does not imply that Kraus et al. (1983) were necessarily wrong, or that others at the Workshop were correct in suggesting that significant calving might occur elsewhere (as was also suggested for the Argentinian population). Kraus et al. (1983) could probably argue with some justification that their counts in fact represented the real reproductive increment for the year, which one might call NJSR (net juvenile survival rate). It will, after all, be those calves which survive to sexual maturity which will contribute to the future population growth.

One disturbing point was raised at the Workshop by Aguilar (1983) who indicated that records suggested that the proportion of calves on the winter grounds of the Bay of Biscay in the Basque fishery period was about 30%. Since there was almost certainly segregation of mothers with calves from most other adults, as can be observed today on the coast of Argentina and on the eastern North American coastal shelf, this figure is certainly far too high to be used to estimate GARR, but does suggest that the net calf survival could have been significantly higher than today. This is just speculation. On some of the southern hemisphere whaling grounds the proportion of calves apparently approached 50%.

Considerations of the potential growth have already been dealt with in the section on population trends; there is no evidence of increase. On the other hand, there is no evidence of a significant decline. Nor can the balance of these two statements be used to suggest that the populations are stable! This is the deplorable state of our knowledge — one that we will not easily improve without much more research. If the GARR is in fact between 7–9%, but the manifested result is only 4–5% of real productivity, and the total population size is assumed to be only 150 (conservative best estimate), it can be assumed in turn that the population's reproductive rate and production are probably already at the maximum that the existing (undefined) carrying capacity of the

environments and the constraints imposed by the life cycle permit.

If the adult mortality rate is about 4%, then the real rate of increase could be from 1–3% per annum.

It would conservatively take at least 15 to 20 years to detect a significant change with any certainty, given the large variance that results from standard census techniques of these clumped animals. The situation might be improved if a coordinated scheme were set up to monitor recognizable individuals and their reproductive history, but even this does not assure success. The only rational approach to a species in this condition is continued total protection on both coasts of Canada. No one could be sure what other steps, beyond those already taken, could be useful.

Species Movements: The Right Whales of both coasts of Canada are migratory, but the migrations are more diffuse than those of the Gray Whale or the Humpback Whale. While consistent summer grounds can be recognized, sightings during the winter months are fewer and more dispersed (Reeves et al. 1978; Herman et al. 1980). The summer grounds probably represent the major point of vulnerability, since tens of animals are gathered together for periods of one to three or more months. Residency time of Right Whales in western Canadian waters is not known; in the Bay of Fundy, they are present from June or July (in relatively small numbers) through August and September (relatively high numbers) to at least late October and November (numbers not ascertained quantitatively, only from opportunistic sightings).

Blandford whaling operations (limited to the whaling season) logged Right Whale sightings in the Browns Bank region in the months of August–October, and in the mouth of the Northeast Channel in July and August. As indicated earlier, spring sightings are concentrated in the vicinity of Cape Cod. One unconfirmed report of a Right Whale in the Bay of Fundy is from early December. Whale sighting effort in the region is so low in winter that there is no way of knowing at present how many spend even longer there. Weather conditions are rarely good for whale observation after October, and even in October 1983, only a few days could be worked with success because of the wind.

Several research groups have reported confirmed sightings of recognizable individual Right Whales from each of the major concentration areas. The minimum straight-line movements that would be involved are shown in Figure 3; data are drawn from Winn (1982) and include resightings within the same year and in different years. It is not yet clear how extensive interchanges are between the Bay of Fundy and Browns Bank. The work recently published by Kraus, Prescott and Stone (1983) revealed that 3000

of the observed long-term and long-distance resightings of recognizable individuals included exchanges from one area to the other, including one which moved from Browns Bank to the Bay of Fundy within one season.

None of the areas of concentration are protected, except in terms of protection from hunting and most harassment. The whole Georges Bank region is potentially available at some time for exploratory oil drilling, although not all areas are included in the immediate lease. There may be areas of winter concentration somewhere on or beyond the coastal shelf between Georgia and Florida, but if these exist, they have not yet been identified. Within the summer zones, areas consistently occupied by mothers with calves are less extensive than the overall range; however, there is not a clear bias to inshore areas, as might have been expected from the Old Bay whaling records (see Winn 1982; Kraus and Prescott 1982; International Whaling Commission 1983). This raises the important question of whether or not loss of inshore wintering habitat to females with calves is a significant controlling factor in restricting numerical recovery of the population.

Behavioural Adaptability — Tolerance to Human Disturbance, Habitat and Food Specialization, Response to Change: Most points have been covered above. It is worth pointing out that Right Whales soon seem to become wary of close approaches by boats, but it is not clear if they retain memory of such disturbance for more than a day or two since they do not show completely consistent reactions. When engaged in mating they frequently appear oblivious to close passage of small vessels, especially if no engine is used. Continual disturbance by vessels, however, would almost certainly disrupt what seem to be their normal behaviour patterns, which in the Bay of Fundy sometimes seem to have a tide-related rhythm. It is worth pointing out that the large tidal amplitude and consequent strong currents of the Bay of Fundy are not typical of most of the Atlantic seaboard. It seems unlikely that rapid deterioration of the food supply, or the offshore habitat, is imminent. The long-term response of the species to change is a matter for speculation. We may in fact be seeing a population that has adapted to significant loss of coastal habitat on both east and west coasts. The response may have been 'stabilization' of numbers at a much lower level than those of the pre-hunting populations.

Limiting Factors

The most likely limiting factor is loss of inshore habitat, followed by competition for patchy food resources by herring, seabirds and perhaps the Sei Whale. It is not likely that predation is a serious

problem for such a large animal, although one with a bite-shaped gash in its flank has been noted; although this might have been a propeller gash, the configuration suggests a bite by a large Great White Shark, *Carcharodon carcharias*, of which a number of records have been published for the Fundy region in recent years. With the growth of interest in whale watching, this species is already drawing special attention (Reeves et al. 1983), and the influence in the near future of a significant increase in boats coming to the concentration areas to observe these animals should not be ignored.

Special Significance of the Species

The Right Whale varies from "rare" to "endangered" throughout its world range. North American coastal waters support two out of the three northern hemisphere populations which (realistically) seem to have any hope of long-term survival. Public interest in, and awareness of, the species was aroused by the release of the National Geographic film on the Argentine population some ten years ago. For the first time a population of large baleen whales had been found in an accessible, shallow water location with reasonably clear water, where the animals stayed for many weeks. This permitted all facets of their behaviour to be observed, filmed and analyzed in unprecedented detail, and was bound to attract attention. With the discovery of another population (albeit not quite so accessible) on the eastern seaboard of North America, much closer to major institutions and universities with facilities for such work, a steady stream of journalists and film makers have sought information and contact with these animals.

The entire taxonomic unit comprising the Family Balaenidae is represented by only three species: the northern and southern hemisphere populations of the Right Whale, the Bowhead Whale, and the Pygmy Right Whale, *Caperea marginata*, which is probably circumpolar in the subpolar and temperate latitudes of the southern hemisphere. The European stock of *Balaena mysticetus* is almost extinct; only one or two sightings have been reported in the last few decades. The western North American stock (Davis Strait, Baffin Bay, Lancaster Sound, Hudson Strait) is very small, perhaps a hundred at most. The eastern Arctic population (Bering Sea, Chukchi Sea, Beaufort Sea and Amundsen Gulf) is presently estimated to number about 3489 ± 458 (IWC Scientific Committee Report 1983, Subcommittee on Protected Species: 12), with from 16 to 34 animals struck each year and population trends not established despite intensive research work.

The Pygmy Right Whale has never been hunted commercially, although two have been taken on Scientific Permit by commercial whalers. What little

is known of the population biology was reviewed by Davies and Guiler (1957), Gaskin (1968, 1982), Ivashin et al. (1972), Ross et al. (1975), and Watson (1981). The population size is probably some thousands in each sector of the southern hemisphere in which it occurs. It is in no danger of commercial exploitation, but since it spends a significant proportion of the summer in shallow warm-water bays in temperate-subtropical latitudes, it might eventually be vulnerable to other forms of human activity alluded to earlier with respect to the Right Whale. The Pygmy Right Whale is not only far smaller than its two relatives, but differs from them in so many anatomical and morphological characteristics that it is usually given separate status not only as a genus, but also within a separate sub-family Neobalaeninae.

With respect to the two species of large balaenid, no population of either taxon can be considered particularly secure from potential extinction on a decadal scale. The large balaenids feed consistently lower in the marine food chain than any mammal (other than the dugongs and manatees and the Sei Whale), represent an archaic yet highly specialized lineage of great scientific interest, can be studied in accessible areas with great yield of generally useful information on whale behaviour, and merit maximum effort to secure their indefinite survival.

Evaluation

It is evident that remorseless commercial hunting was responsible for reduction of the Right Whale populations to the present low levels. It is probable that some recovery has taken place since the 1930s, when full protection was given (except in South American waters, and taking into account the local atrocity by the USSR at Tristan in 1958), but the magnitude of this recovery cannot be measured. Apparent extensions of range by some populations today may be real, or may result only from greatly increased awareness, more observers in more localities, and increased ability to distinguish the species accurately from other large whales. The potential for significant increases in population size is similarly not known. All that can be done at present is protect the species and its apparent habitat within practical constraints.

Given that even the most optimistic estimates place the maximum population size in the low hundreds, and that the reproductive rate appears to be very low, any factor further decreasing the latter would have a markedly detrimental effect on the status of the species in the western North Atlantic. At this stage, no change is recommended in the present status of the Right Whale as an endangered species.

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Literature Cited

- Aguilar, A.** 1983. A review of old Basque whaling and its effect on the right whales of the North Atlantic. Document SC/35/RW/1. Workshop. Report on the Status of Right Whales, Boston, June 1983. International Whaling Commission.
- Allen, J. A.** 1908. The North Atlantic Right whale and its near allies. Bulletin of the American Museum of Natural History 24: 277-329.
- Best, P. B.** 1981. The status of right whales (*Eubalaena glacialis*) off South Africa. Investigative Report of the Sea Fisheries Institute of South Africa 123: 1-44.
- Brodie, P. F.** 1981. A preliminary investigation of the energetics of the Bowhead whale (*Balaena mysticetus* L.) Report of the International Whaling Commission 31: 501-502.
- Davies, J. L., and E. R. Guiler.** 1957. A note on the pygmy right whale *Caperea marginata* Gray. Proceedings of the Zoological Society of London 129: 579-589.
- Garrett, C. J. R., J. R. Keeley, and D. A. Greenberg.** - 1978. Tidal mixing versus thermal stratification in the Bay of Fundy and Gulf of Maine. Atmosphere-Ocean 16: 402-423.
- Gaskin, D. E.** 1968. The New Zealand Cetacea. Fisheries Research Bulletin, New Zealand Marine Department (New Series) 1: 1-92.
- Gaskin, D. E.** 1972. Whales, dolphins and seals: with special reference to the New Zealand region. Heinemann Educational Books, Auckland and London.
- Gaskin, D. E.** 1976. The evolution, zoogeography and ecology of Cetacea. Oceanographic Marine Biological Annual Review 14: 247-346.
- Gaskin, D. E.** 1982. The ecology of whales and dolphins. Heinemann Educational Books, London.
- Greenberg, D. A.** 1978. A numerical model investigation of tidal phenomena in the Bay of Fundy and Gulf of Maine. Marine Geodesy 2: 161-187.
- Hamner, W. M., and I. R. Hauri.** 1977. Fine-scale surface currents in the Whitsunday Islands, Queensland, Australia: Effect of tide and topography. Australian Journal of Marine and Freshwater Research 28: 333-359.
- Hay, K. A.** 1985. Studies of the Right Whale, *Eubalaena glacialis*, in Canada. Canadian Field-Naturalist 99(3): 433-437.
- Herman, L. M., C. S. Baker, P. H. Forestell, and R. C. Antinofa.** 1980. Right Whale (*Balaena glacialis*) sightings near Hawaii: a clue to the wintering grounds? Marine Ecology Progress Series 2: 271-275.
- International Whaling Commission.** 1983. Workshop Report on the Status of Right Whales, Boston, Massachusetts, June 17-23. Document SC/35/Rep/2.
- Ivashin, M. V., V. I. Shevchenko, and V. L. Yukhov.** 1972-. [Pygmy right whale *Caperea marginata* Cetacea]. Zoologicheskii Zhurnal 51: 1715-1723.
- Kawamura, A.** 1978. An interim consideration on a possible interspecific relation in southern baleen whales from the viewpoint of their food habits. Report of the International Whaling Commission 28: 411-419.
- Klumov, S. K.** 1962. [Right whale (Japanese) of the Pacific Ocean]. Trudy Instituta Okeanologii 58: 202-297.
- Kraus, S., and J. H. Prescott.** 1981. Distribution, abundance and notes on the large cetaceans of the Bay of Fundy, summer and fall 1980. Final Report to U.S. Department of Commerce, National Marine Fisheries Service, Contract NA-80-FA-00048.
- Kraus, S., and J. H. Prescott.** 1982. The North Atlantic Right whale (*Eubalaena glacialis*) in the Bay of Fundy, 1981, with notes on distribution, abundance, biology and behaviour. Final Report to the U.S. Department of Commerce, National Marine Fisheries Service, Contract NA-81-FA-00030.
- Kraus, S., and J. H. Prescott.** 1983. [Abstract] The use of callosity patterns and natural markings to determine distribution, abundance and movements of the North Atlantic Right whale, *Eubalaena glacialis*. Fifth Biennial Conference on the Biology of Marine Mammals, November 27-December 1, 1983, Boston.
- Kraus, S. D., J. H. Prescott, and G. Stone.** 1983. Right whales in the northern Gulf of Maine. Whale Watcher 17(4): 18-21.
- Matthews, L. H.** 1932. Lobster-krill: Anomuran Crustacea that are the food of whales. Discovery Report 5: 467-484.
- Matthews, L. H.** 1938. Notes on the southern right whale, *Eubalaena australis*. Discovery Report 17: 169-182.
- Mitchell, E. D.** 1974. Present status of northwest Atlantic fin and other whale stocks. Pages 108-169 in The whale problem: a status report. Harvard University Press, Cambridge, Massachusetts.
- Mitchell, E. D.** 1975. Trophic relationships and competition for food in northwest Atlantic whales. Pages 123-133 in Proceedings of the Canadian Society of Zoologists, 1974.
- Nemoto, T.** 1957. Food of baleen whales in the northern Pacific. Scientific Report of the Whales Research Institute 12: 33-89.
- Nemoto, T.** 1959. Food of baleen whales with reference to whale movements. Scientific Report of the Whales Research Institute 14: 149-290.

- Nemoto, T.** 1962. Food of baleen whales collected in recent Japanese whaling expeditions. Scientific Report of the Whales Research Institute 16: 89–103.
- Ohsumi, S.** 1981. [Abstract] Interspecific relationships among biological parameters concerned with reproduction in the cetaceans. Report of the International Whaling Commission. Special Issue 6.
- Ohsumi, S., and S. Wada.** 1974. Status of whale stocks in the North Pacific, 1972. Report of the International Whaling Commission 24: 114–126.
- Omura, H.** 1958. North Pacific right whale. Scientific Report of the Whales Research Institute 13: 1–52.
- Omura, H., S. Ohsumi, T. Nemoto, K. Nasu, and T. Kasuya.** 1969. Black right whales in the North Pacific. Scientific Report of the Whales Research Institute 21: 1–78.
- Payne, R.** 1981. [Abstract] Reproductive rates and breeding occupancy in the southern right whale, *Eubalaena australis*. Conference of Cetacean Reproduction: estimating parameters for stock assessment and management. La Jolla, California, November 28–December 7, 1981.
- Reeves, R., S. Kraus, and P. Turnbull.** 1983. Right whale refuge? Natural History Magazine 92(4): 40–45.
- Reeves, R., J. G. Mead, and S. Katona.** 1978. The right whale, *Eubalaena glacialis*, in the western North Atlantic. Report of the International Whaling Commission 28: 303–312.
- Ross, G. J. B., P. B. Best, and B. G. Donnelly.** 1975. New records of the pygmy right whale (*Caperea marginata*) from South Africa, with comments on distribution, migration, appearance and behaviour. Journal of the Fisheries Research Board of Canada 32: 1005–1017.
- Showell, M.** 1984. Cadmium and lead in the seston of the Bay of Fundy: distribution and partitioning. M.Sc. thesis, University of Guelph, Guelph, Ontario.
- Smith, G. J. D., D. E. Gaskin, and M. Brander.** 1981. A study of the formation, content, persistence and movements of mobile seaweed patches in the Quoddy region, western Bay of Fundy, and their role in the inshore pelagic ecosystem. Final Report on DSS Contract OSC-80-00126, submitted to Department of Fisheries and Oceans, Ottawa, Ontario.
- Sutcliffe, W. H. Jr., and P. F. Brodie.** 1977. Whale distributions in Nova Scotia. Fisheries and Marine Service Technical Report 722: i–vi and 1–82.
- Wada, S.** 1976. Indices of abundance of large-sized whales in the North Pacific in the 1974 whaling season. Report of the International Whaling Commission 26: 382–391.
- Watkins, W. A., and W. E. Schevill.** 1979. Aerial observations of feeding behaviour in four baleen whales: *Eubalaena glacialis*, *Balaenoptera borealis*, *Megaptera novaeangliae*, and *Balaenoptera physalus*. Journal of Mammalogy 60: 155–163.
- Watson, L.** 1981. Sea guide to whales of the world, Nelson Canada Limited, Scarborough, Ontario.
- Whitehead, H., and R. Payne.** 1981. New techniques for measuring whales from the air. Report to the U.S. Marine Mammal Commission in fulfillment of Contract MM6-AC-017, Marine Mammal Commission Publication MMC-76-22.
- Winn, H. E.** 1982. A characterization of marine mammals and turtles in the mid and North Atlantic areas of the U.S. Outer Continental Shelf. Final report of Cetacean and Turtle Program (CeTAP), contract No. AA551-CT8-48 to the Bureau of Land Management, U.S. Department of the Interior, Washington, D.C.
- Winn, H. E., C. A. Price, and P. W. Sorensen.** 1983. [Abstract] Distributional biology of the Right whale in the western North Atlantic. Fifth Biennial Conference on the Biology of Marine Mammals, Boston, Massachusetts, November 27–December 1, 1983.
- Workshop Report on the Status of Right Whales.** 1983. International Whaling Commission, Boston, Massachusetts. June 17–23, Document SC/35/Rep/2.

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Book Reviews

ZOOLOGY

Ornithology in Laboratory and Field (Fifth Edition)

By Olin Sewall Pettingill, Jr. 1985. Academic Press, Orlando, Florida. xi + 403 pp., illus. U.S.\$32.40.

Ornithology is a text for college or university use, intended to give the student a basic grounding in the major aspects of the science of birds. It is divided into 22 chapters which cover the physical structure and appearance of birds, distribution and identification, behaviour and migration, and the entire process of procreation, population and evolution. Four appendices give supplementary guidance in photography, voice recording, banding and similar activities, and preparing a paper, as well as a comprehensive list of journals.

This is a well-written text book. Pettingill is the principal author, but various other ornithologists have made major contributions. The style, however, is consistent throughout. The format is clear, well organized and allows the reader to key in on significant paragraphs or key words with ease. I tried several times to find specific pieces of information again and was quickly successful on every occasion. This will be a great asset to those who must suffer with exams and the necessary revision. The prose is written in a precise, smooth flowing style that makes the text easy and, indeed, pleasant to read. I found only the chapter on "Anatomy and Physiology" to be heavy going, with its mass of Latin-based names for the formidable array of internal parts.

This book is clearly meant as an introduction. The reader who wishes to go deeper into any section is given an excellent and extensive list of references. The author has been careful to point out where controversy exists and has named the conflicting papers.

Although I could find little to criticize in this book, it is not perfect. I found the chapter on "Longevity, number and populations" to be a bit thin in its discussion of populations (a mere 3½ pages). I think this section should be expanded with some discussion

on the fascinating aspects of population controls and dynamics. There are two areas where the text is confusing. For example, the section on arctic tundra can be read to imply that the rainfall is moderate to heavy. (Arctic tundra is classified as semi-desert!) The page numbers given for some of the headings in the "Contents" are wrong. (They are correct in the Index.) These are all minor criticisms.

The book is illustrated with black-and-white drawings by Walter Breckenridge. Where these drawings serve a technical purpose, they are clear and relate to the text. There are many that have been added for decoration as well. All are professional and artistic, but none are captioned to identify the species illustrated, an omission in a book intended as an introductory text. Each chapter heading is accompanied by a small drawing, many of which are delightfully humorous.

I believe this book deserves a wider readership than the college circuit. There are many areas where the data base is poor or non-existent. Much valuable information could be gathered by amateurs, thus providing an invisible supplement to the inadequate supply of research resources. I would hope that some birders can be encouraged to broaden their interests beyond simple listing and rarity chasing, and undertake some more basic investigations. Reading this book will be the basis needed to get started.

In summary, I strongly recommend this book for its intended purpose, as an introductory text for ornithology. I would also suggest that all enthusiastic birders should add it to their library, even if not to read, as a basic reference. But this is not a book to gather dust. It should be used often to gain a better understanding of those fascinating creatures, birds.

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A Guide to the Birds of Lancaster County, Pennsylvania

Editorial Chairman: Harold B. Morrin. 1984. Lancaster County Bird Club, Lancaster, Pennsylvania. 188 pp., illus. U.S.\$8.96.

Birds of Lancaster County, Pennsylvania has been produced by a committee of the Lancaster County Bird Club. The standard cliché for a committee is that if it were asked to design a horse it would, because of the inevitable conflicts, produce the functional but inelegant camel. This committee, however, was obviously harmonious and has produced a very useful guide to the region.

The book begins with two short sections on habitat and history, and on geology and topography. The main section of the book follows and covers, in twelve chapters, the most interesting birding locations within the region. Each chapter takes a specific area of Lancaster County and begins with a short description of the area itself. This is followed by a detailed description on how to find each location of interest. Particular attention is paid to describing lookouts and vantage points, and suitable parking places are clearly identified. Each of these descriptions is accompanied by a clear, easy-to-follow map. Important features, such as the viewpoints, access points and parking areas mentioned above, are clearly marked on the map. The chapter continues by describing, in reasonable detail, the birds likely to be found in that

area at any time of the year. The likely status of each species is also mentioned.

Where appropriate, these chapters include additional useful information, such as a list of rarities with dates for the most productive locations, or the results of special censuses. There are numerous illustrations, donated by five artists, which vary somewhat in quality.

There is a special chapter on the occurrence of Gyrfalcons and the book finishes with an annotated checklist. This checklist is a straight-forward, useful adjunct to the main chapters. The book ends with an index of birds by species. It does not include an index to the prime locations. On checking the rare shore birds sighted in this region, I discovered that one location, Conejohela Flats, is obviously the best place for these birds. Since locations are not included in the index, it requires a major effort to find such places.

The Lancaster County Bird Club is to be complimented for producing this book. They have shown what can be done with a cooperative committee effort. I hope that other clubs will be inspired to work on their own contributions to the regional guides of North America.

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Bird Conservation 2

Edited by Stanley A. Temple. 1985. University of Wisconsin Press, Madison. 181 pp. Cloth U.S.\$17.50; paper U.S.\$12.95.

Like the first issue of this "annual" series of publications by the American section of the International Council for Bird Preservation (reviewed by Stephen Gawn *Canadian Field-Naturalist* 99: 556, 1985), this second volume is divided into three sections. The bulk of the text (pp. 3-159) covers five papers on island birds. These are followed by a short news section updating previous contributions on Peregrines and California Condors and a 14-page review of recent literature.

Editor Stanley Temple introduces the theme in an excellent four-page summary of biological and physical factors that make island species and races more vulnerable than their mainland counterparts. The principles and factors outlined apply equally to other life forms, and one could easily substitute any faunal or floral division for avian in his chilling statement: "It seems inevitable that the colonization

of an island by human beings will result in avian extinctions." Detailed examinations of three United States-controlled island regions provide examples of the principles summarized by Temple. A review of historical and current factors impinging on Hawaiian native birds by C. John Ralph and Charles Van Riper III is nicely complemented by an annotated examination of each of these species by J. Michael Scott and Cameron B. Kepler. Their task was relatively easy compared with that of John Engbring and H. Douglas Pratt. The latter found that for many of the Micronesian islands the most recent data available dated to World War II or back even further to explorations by late nineteenth and early twentieth century explorers.

More recent surveys on some of these diverse islands indicate that some officially "endangered" species are relatively common, while this good news is offset by others not listed that are in serious trouble. A sharp, sudden decline involving birds of all sizes, food habits, nesting habits, and flying abilities on Guam to

the point where in 1981 most native species occupied only 5 to 15% of their historical distribution "may become the greatest avian disaster of the half-century" if the cause(s) is/are not determined in time to take corrective measures. James Wiley's review of bird conservation in Puerto Rico and the U.S. Virgin Islands adds more examples of problems outlined in other areas. Not all is gloom here, as some successful programmes are discussed, and some species, such as the recently discovered Elfin Woods Warbler, are more widespread than previously thought. Amazingly, surveys inspired by the 1961 discovery of a population of the Puerto Rican Nightjar, thought extinct for 70 years, revealed a population of about 450 to 500 pairs, and partial subsequent surveys indicate a steady population, provided that sufficient remnants of *dry* forest are retained for this species. One would hardly expect cessation of bombing to pose an environmental problem, but the resultant lack of associated fires on Culebra has allowed vegetation to encroach on seabird breeding areas, combining with increased poaching to produce marked population reductions there.

Although the examples covered in *Bird Conservation 2* involve primarily birds on tropical islands, the problems they face and principles of island biogeography affecting them are common to distinct floral and faunal forms of various taxonomic levels on Sable Island, islands in Lake Erie, the Queen Charlotte Islands, and many other areas of Canada. Problems posed by cuts in funding to the Puerto Rican Parrot recovery program will strike a responsive note in Canada, as will the threats posed by marked deforestation in many areas. Establishment of a second Whooping Crane population in Idaho by Canadian and U.S. officials was done to reduce the

danger posed to a closed population by catastrophic events, and other "island" principles also apply to some extent in mainland regions. Problems posed to the Hawaiian Duck by interbreeding with Mallards parallel the dangers of Mallard-swamping to the American Black Duck in some areas, and the effects of Shiny Cowbirds expanding their range on small birds in Puerto Rico sound similar to problems posed to North American species by range expansion of the Brown-headed Cowbird. Canadian naturalists will be pleased to learn that since released peregrines first established a breeding pair in 1978, the number of breeding pairs has doubled about every two years in the eastern U.S., suggesting that pre-DDT levels can be regained by 1990 if trends continue.

Like the first issue, this volume is written well, with remarkably few errors. Since this is only the second volume, Gochfeld's 1983 paper on Roseate Terns could not possibly be in volume 25, and it was in fact published in *Biological Conservation*. The belief that Newton's Screech-Owl became "extinct" on St. Croix (p. 146) would have more accurately been termed "extirpated" had not the rediscovery of the bird there made this terminology irrelevant. The source of "dispersion" of Rhesus Macaques mentioned on p. 144 should have referred to "dispersal." Apart from these minor errors, I found only three lapses in proof-reading, and I share Stephen Gawn's enthusiasm for this series. As Chairman of the Canadian section, I wish we had the resources to produce something comparable, and I await the third annual with eager anticipation.

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Bear Attacks: Their Causes and Avoidance

By Stephen Herrero. 1985. Winchester Press (Canadian distributor Hurtig, Edmonton). 287 pp., illus. Cloth \$19.95; paper \$12.95.

This book is about the Black Bear, *Ursus americanus*, the Grizzly Bear, *Ursus arctos*, and the people who interact with both species in the modern world.

The book is divided into 17 chapters. In chapters 1-8, Dr. Herrero provides explicit accounts of people-bear conflicts using records and personal accounts from the literature, management reports, personal correspondence, and interviews. He analysed these detailed records in order to uncover the reasons for the conflicts. Of the 414 descriptions collected between 1872 and 1980, 357 involved injury or

aggression. Despite these incidents, Dr. Herrero maintains that "one's chances of being injured by a grizzly bear are small if proper precautions are taken." This is exemplified by the fact that hundreds of thousands of people visit bear country every year in Canada and the United States, and few injuries occur.

Chapters 1-8 include: Grizzly Bear Attacks, Sudden Encounters With Grizzlies, Provoked Attacks, The Dangers Of Garbage And Habituation, Other Attacks, Aggression Without Injury, The Tolerant Black Bear, and the Predacious Black Bear. Dr. Herrero teases out valuable information about bear behavior and response, human response, and recommendations for preventing or minimizing the effects of an encounter.

Chapters 9–10 provide information which people interested in safety might want to know about living and working in bear country. Dr. Herrero tries to “present enough information so that [the reader] can start to sense the environment as a bear does.” Chapter 9, *Avoiding Encounters*, concentrates on trip planning; it is recommended that people living and working in bear country learn about the behavior, ecology, and management of bears. This chapter includes sections on travelling, camping, bear repellents (eg. noise, chemicals, electric fencing, and rubber bullets) and attractants. Techniques which can be employed to detect and deter bears are briefly described; the reader is referred to more detailed work on each technique in a list of notes (including references) at the end of the book.

The characteristics of Grizzly Bears and Black Bears (eg. morphological and physical features) are summarized in Chapter 10, while the evolution of bears is addressed in Chapter 11. The types and location of bear foods are described in Chapter 12. Dr. Herrero feels that by learning to recognize feeding areas, people travelling in bear country can improve their ability to avoid sudden encounters. He addresses spring and summer foods, midsummer to fall foods, travel routes, and important habitat types (eg. bedding areas, den sites, mating areas, and escape cover).

When living and working in bear country, signs (tracks, droppings, diggings, carcasses, etc.) provide important clues about the distribution of bears. In chapter 13, Dr. Herrero provides some interesting and useful clues about reading the natural environment for bear activity.

Bears are not “simple stimulus-response machines. Each bear is an individual with a personality and a specific set of experiences.” Chapter 14 focuses on bear curiosity and exploration, discrimination and generalization, and habituation and avoidance. The underlying principle in this review is that the variability in bear behavior is significant, even in cases where the factors contributing to a behavioral response are similar. Understanding bear behavior, as difficult as it may be, is critical to people living and working in bear country should they have to make quick decisions about how to deal with a specific type of encounter.

In Chapter 15, Dr. Herrero discusses bear aggression and submission by using two concepts: understanding Black Bears and Grizzly Bears, and using this knowledge to enhance human safety in bear

country. The chapter concentrates on the general characteristics of aggression and submission, evolution and aggression in female bears, and how Grizzly Bears and Black Bears express aggression.

Chapter 16, “Bears And People In Rural And Remote Areas,” is devoted to a summary of techniques which people can employ to enhance their safety and to minimize the risk of encounter. The summary includes garbage and garbage dumps, break-ins, safety for children, bears and bees, bears and fruits and vegetables, livestock, years of food-crop failure for bears, backstripping and sapwood ingestion, and predator control specialists. The summaries are brief; readers interested in more detail about specific situations can consult the references cited by Dr. Herrero. This chapter also contains information about techniques which can be employed to establish and run remote camps, and a summary on the use of firearms.

Although a significant amount of work has been completed in this field in the last decade, a great deal remains to be done. In Chapter 17, Dr. Herrero concludes his book by discussing bear management and by describing some of the unresolved questions which face us. Some of the questions include: where to locate trails and campgrounds, and the levels and type of use which should be permitted; what to do with problem bears; and how to effectively communicate essential information about bears to the public.

One of the few criticisms I have about this book is the manner in which the recommendations are presented. Throughout the text, Dr. Herrero develops and thoroughly rationalizes each recommendation on the basis of his analyses of encounters. The recommendations are very useful to people planning to spend time in bear country; however, it would have been nice to see a chapter summarizing all of the recommendations for those wishing to quickly refresh their memory.

The book contains a number of black-and-white photographs, drawings, figures, and tables. I recommend this book to all who live and work in bear country, and to those interested in the art(?) and science(?) of people-bear management in the modern world.

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North American Waterfowl Management Plan

By the Canada-United States Steering Committee. 1985. Environment Canada and U.S. Fish and Wildlife Service. Environment Canada, Ottawa. 37 pp., illus. Free.

Waterfowl are the most prominent and economically important group of migratory birds in North America, generating in excess of several billion dollars of expenditures annually. However, their migratory habits generate complex international overtones on their management and necessitate co-ordinated efforts between North and Central American nations. This North American Waterfowl Management Plan is a long-needed and optimistic attempt by a joint Canada-United States Steering Committee to identify major waterfowl management problems, establish objectives, and propose a series of strategies for solutions, all within a 15-year framework.

The plan concerns the 37 species of ducks, geese, and swans in the family Anatidae that regularly occur in both the United States and Canada. Biologists have determined that the loss and degradation of nesting, migration, and wintering habitat is the major waterfowl management problem in North America. Agricultural practices, industrial development, and summer recreation have reduced the quality and quantity of waterfowl habitat and have contributed to long-term downward trends in some important duck populations. This plan provides both general and specific strategies to achieve desired population objectives, primarily through acquisition and improvement of habitat, international fund raising, and education.

One of the goals of the plan is to continue to provide the two million or so active waterfowl hunters in the United States and Canada with their annual opportunity to harvest 20 million ducks, about one-fifth of the average fall flight. There are contingencies built into the plan to reduce this harvest if waterfowl population levels fall below predetermined levels. This plan points out one weakness in the continental approach to waterfowl management in that virtually no data exist on what role Mexico and the other Central American countries play in both the ecology and the harvest of waterfowl. Finally, the plan announces the establishment of a North American Waterfowl Advisory Committee to monitor and update the plan, co-ordinate current work, review new proposals, and suggest recommendations for actions within the scope of the plan to the federal wildlife agencies of Canada and the United States.

I strongly recommend this document to anyone who is concerned about waterfowl. As well as providing some interesting facts and figures, it will give the reader some insight into the current state of wildlife management and how legitimate biological concerns have to be tempered by today's political realities. We can only hope that the hopeful spirit of international co-operation so evident in this document will not drown in the same slough of political inertia that has claimed biologists' hopes for prompt action on the acid rain problem.

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A Field Guide to Atlantic Coast Fishes of North America

By C. Richard Robins and G. Carleton Ray, illustrations by John Douglass and Rudolf Freund. 1986. Houghton Mifflin Company, Boston. xi + 354 pp. + 64 plates. U.S.\$14.95.

This is the latest volume in the Peterson Field Guide Series and follows the familiar format. There is also a *Field Guide to Pacific Coast Fishes of North America* (1983) and the freshwater guide is eagerly awaited. The Atlantic coast is taken to be that stretch of coast from the Canadian Arctic to the Gulf of Mexico. This includes Hudson Bay and the southern Arctic islands in the north, but fewer than one third of the Bahamian and Caribbean fishes are included for the south. There are no distribution maps, but since the guide encompasses coastal fishes, the northern and southern limits and depth distribution give an adequate measure of where fishes may be found.

The guide does not include freshwater fishes which rarely stray into brackish waters, or deepwater species and open sea species that stray into coastal waters. This still leaves over 1000 species, twice the number of bird species in eastern North America. These limitations were no doubt necessary to make the guide manageable.

Nevertheless, this large number of species makes identification a problem. Those users new to fishes would have to put in a lot of work to identify some species. Some families are notoriously more difficult than others, as any experienced ichthyologist can tell, but the guide does not always offer warnings.

The guide groups fishes having a similar appearance on plates, and arrows indicate distinguishing features. There is no indication of size on these plates, a character which can often eliminate species from

consideration when identifying. Some groupings are necessarily strange both to professionals and amateurs. Plate 8 has sturgeons, trouts, and lancetfish, all very different in appearance and well-separated in the text. I would have preferred a pictorial and text key to families to break the diversity into more manageable units. It might then have proved possible to have plates facing the text description, which is always the easiest format for using a guide.

The common names follow the 1980 American Fisheries Society checklist. Rarely are other common names included. I must admit to being a little vague on why a standard common name is needed. Scientific works must mention the scientific name or be regarded as less than scientific. As long as the common name is internally consistent to that work, it matters not to me what it is. Popular works on fishes are ever unlikely to be assiduous users of official common names. Fish are not birds where common names are fairly well fixed. In fishes intriguing and instructive agglomerations of common names can and are applied to a single species, sometimes usefully denoting life history stages. The variety of common names could have been included, in fine print, as an aid to local users without any particular increase in length of the book. Speckled trout, for example, is still often used for Brook Trout, *Salvelinus fontinalis*, but is not mentioned here. This can only be confusing to users unfamiliar with or overawed by scientific names. There are no French names provided.

The identification of closely related species could be enhanced by more text figures to show anatomical key characters. Such figures save the exasperating search

for the precise meaning of technical descriptive words, which are always a stumbling block for the amateur or casual user of guides. Some characters would leave even professionals confused: the distinction between shallowly forked and slightly forked is no doubt real but subtle.

Various errors occur through the book but these are not excessive. The Bonefish and Atlantic Sturgeon on plate 8 are not labelled. It is incorrect to state that the Blackspotted Stickleback has no bony plates on the sides. Plates are evident on the figure of this species and may extend along the whole flank in some American populations. The seagoing Atlantic or Acadian Whitefish, *Coregonus canadensis*, is omitted. Admittedly, it is now few in numbers because of acid rain and habitat alteration but it would have been nice to see this uniquely Canadian species included. Some keys do not work very well because they must generalize, a problem of all field guides, e.g. the Spot, *Leiostomus xanthurus*, a popular panfish, is distinguished by being the only drum in the area of the guide with a distinctly forked caudal fin. True enough for adults but not for smaller specimens. The index is arranged in that annoying way "Trout, Brook" with nothing under "Brook Trout".

Despite these quibbles, this is a most useful book serving as a rapid introduction to the diversity of Atlantic coast fishes.

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A Pictorial Guide to the Birds of the Indian Subcontinent

By Sâlim Ali and S. Dillon Ripley. 1983. Oxford University Press, Don Mills, Ontario. 177 pp., illus. \$35.75.

Given the reputation of the two authors, and the illustrator, John Henry Dick, I awaited the arrival of this book with great anticipation. The Bombay Natural History Society sponsored this work to provide an inexpensive, fully illustrated guide to the birds of the Indian subcontinent. This, they felt, would fill a much needed gap in Indian bird literature, and thereby enhance public awareness and conservation. Unfortunately, I found the book very disappointing.

The book begins with a systematic index of families and species. There is a brief description of the general appearance, habits and habitat of each family. Following each description is a sequential list of the members of that family that occur in India. This

listing consumes 62 pages of precious space and does little to assist the observer in field identification.

There then follows 106 plates (34 in black and white and 72 in color). They are arranged with the plate on one page with the text on the opposite page. The authors state that descriptions have been omitted to save as much space as possible. Therefore, the text is limited to identifying the bird in English, with the accompanying Latin binomial, the size relationship to an abundant bird (such as crow or pigeon), and a very brief description of the habitat and geographical location. Each bird is given the species number which corresponds to the ten-volume *Handbook of Birds of Indian and Pakistan* (also by Ali and Ripley) so that they can be cross-referenced. This is followed by a number which identifies the illustration on the facing plate. The order of identification follows the

Handbook sequence and not the sequence in which the birds are illustrated in this volume. I found this very confusing and so obviously did the authors. For example, Long-tailed Duck and Common Goldeneye are mis-identified, as are Brown-winged and Stork-billed kingfishers. A Cream-colored Courser is identified as a Knot and the Indian Edible-nest Swiftlet is identified as a Pallid Swift.

This system means that identification must be based solely on a comparison between the illustration and the observed bird. This puts us at the mercy of two people. First, the illustrator, and the accuracy and completeness with which he illustrates a representative individual bird. Second, we must hope that the printer translates the illustrator's work accurately. North Americans will be able to detect a host of errors in species that are common to both continents. For example, the Little Gull immature does not show a dark cap and the wing bar illustrated is very narrow. The two Common Terns shown had no dark tips to their primaries and the bill on the Roseate Tern is poorly represented. In addition to errors there were omissions; birds like Antarctic Skua are illustrated by a head only, and Pomarine (or Pomatorhine) Skua is shown by tail only. Using this book alone, I would have trouble separating Black, Pariah, and Black-eared kites and would even have trouble with Red Kite. Similar remarks can be made about the owls, female wheatears, pipits, and many of the warblers. At the very least, the authors could have included indicator lines to the most significant field marks (as used by R. T. Peterson). This would have given some reassurance that the most significant feature was not illustrator or printer error.

A Functional Biology of Sticklebacks

By R. J. Wootton. 1984. University of California Press, Berkeley and Los Angeles; Croom Helm, London and Sydney. 265 pp., illus. U.S.\$29.75, £17.95.

This is the second volume in the Functional Biology Series under the general editorship of Peter Calow, University of Sheffield. The first volume was *Free-living Protozoa* by Johanna Laybourn-Parry. The main aim of the series is given as explaining the way organisms "make a living" in nature. This is "the way organisms acquire and then make use of resources in metabolism, movement, growth, reproduction, and so on". The series also examines how selection has produced evolutionary adaptations. The scope for each author is therefore wide.

Sticklebacks are small, but often abundant, fishes of northern waters both fresh and salt. In Canada they

The color printing appears to be reasonable; however, one or two plates in my edition are obviously poorly done. Plate 32, of quails and partridge, has an overall whitewashed appearance and a strange red overlay on the right hand side. Some of the plates are too green as well.

In addition to the above, I have a number of other criticisms. The book itself is not well produced. The paper is of poor quality and my copy arrived with the back completely broken, revealing the scrap paper which had been used as part of the binder. There isn't any index to the plates, only one for the systematic listing of families. Thus, to use the book effectively, you have to learn the sequence of plates by memory. I would also like to see the more careful use of some of the English names, such as using Francolin instead of partridge (Grey partridge is in fact Grey Francolin and not the bird expected in Europe and North America under that name). I would like to see the authors revise and reissue this book, dropping the unnecessary systematic list of families, including a brief, useful description of each bird, adding field mark indicators to the illustrations, revising the numbering system to be less confusing, and eliminating the errors.

One last point. This book measures 26½ by 19½ cm as opposed to 12 by 19 cm for a standard field guide. It certainly will not fit into any of my pockets. However, it is the only fully illustrated portable field guide to the birds of India and until the authors bring out a better upgraded version, it will have to suffice.

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are important components of northern aquatic ecosystems and five of the seven species named by Wootton are found here. There has been an extensive literature on them and Wootton reviewed their biology in an earlier book, *The Biology of Sticklebacks* (1976, Academic Press). The literature of the latest book is about equally divided between pre-1976 works and later works, an indication of the recent coverage by Wootton and the continued interest in sticklebacks. The great interest in sticklebacks is occasioned by their continued use as experimental animals, easy maintenance in aquaria, and the ease with which they can be collected and studied in the field.

The chapter headings summarize areas of research in which these fishes have contributed to our knowledge of how an organism works. They are: 1)

Spatial Distribution which reflects evolutionary and adaptational history and behavioural choices constrained by physiology, 2) Feeding which affects survival, growth, and reproduction, 3) Environmental Factors, Metabolism, and Energetics which in their interactions determine the rate of food consumption and the way energy is partitioned, particularly in respect to reproduction, 4) Growth and Production which determine reproduction potential, 5) Reproduction which is the ultimate test of the biological success of an individual, 6) Inter-specific Interactions where predators have an important effect on the small sticklebacks, notably as a selective factor in evolution, but also on population abundance, 7) Population Dynamics which deals with abundance, apparently cyclical in nature in sticklebacks and the subject of much theoretical and empirical analysis in other organisms, 8) Ecological Genetics in which the peculiar geographical variation in sticklebacks, easily studied under field and laboratory conditions, provides almost unique material for the study of evolution, and 9) Life History Strategy which attempts to show why sticklebacks are so successful,

an attempt aided by their ease of study with relatively unsophisticated equipment. Two chapters, the Introduction and Structure and Function, provide a background for the other chapters.

The book can be recommended to anyone interested in functional biology as it not only reviews literature but provides excellent interpretation by an acknowledged expert on the sticklebacks, without being merely a specialist's book. Areas where further research is needed are pointed out. As might be expected, those parts of the book dealing with reproduction and growth, Wootton's specialities, are particularly well done. The exposition on systematics and genetics is not up to the same level. The wealth of information on sticklebacks is bewildering and Wootton has done a great service to biologists interested in ecology and evolution by digesting and presenting this information in compact form.

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BOTANY

The Vascular Plants of South Dakota (Second Edition)

By Theodore Van Bruggen. 1985. Iowa State University Press, Ames, Iowa. 476 pp., illus., U.S.\$28.95 + U.S.\$1.50 postage.

A review of the first edition of this work published in 1976 was printed in *The Canadian Field-Naturalist* 92(1): 102, 1978. Like the first edition, the systematic part is organized in the fashion of a continuous dichotomous key in which the end of each dichotomy is an expanded species description together with habitat, general locations within the state, flowering time, and common names. The descriptions are largely the same as before, but have been shortened slightly by the use of a few abbreviations and the removal of some synonymy and comments. The major difference between the two editions is the change in the arrangement of the order of the families from that of the Engler and Prantl system to that of the recently published order of Cronquist. This has probably been done to demonstrate the new system to students in taxonomy.

In the nine years between the two editions, 23 species have been added to the known flora of South Dakota, indicating that the author and others interested in expanding the botanical knowledge of the state have been active. The number of genera now

known has increased from 579 to 582 and the number of families from 115 to 126.

The short introduction, which outlines the glacial history, geology, physiography, and climate, remains essentially the same. These features are most useful as an aid to the understanding of the vegetation relationships in the varied terrain of the state.

The text is again typewritten, but in this edition the right hand margin is justified, thus giving the work a more finished look. The page size has been reduced vertically by an inch and one-quarter but in spite of this, more information has been placed on each page. This, together with the other contractions mentioned above, has resulted in a book that has 64 fewer pages. The decrease in size and weight will be much appreciated by students who are carrying it in their packs.

That the flora has been well received is evidenced by the need for a second edition so soon after the first. It is certainly a most useful work.

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The Names of Plants

By D. Gledhill. 1985. Cambridge University Press, Cambridge, UK. viii + 159 pp., illus. Cloth U.S.\$34.50; paper U.S.\$9.95.

The author's aims in writing this book were to provide interesting accounts of the history and procedures of naming plants, and the meanings of plant names. It was written for all those interested in plants, from casual gardeners to professional botanists. Although it may seem to be a daunting task to appeal to such a wide audience, I feel that Gledhill has accomplished his goal admirably. The entire book is written in such a way that a person with limited botanical background can understand it, yet it does not come across as trivial or boring to the professional. Needless to say, this is not a complete glossary of plant names, nor is it a dictionary of botanical terminology. Rather, the author presents a survey of the nature and problems of plant nomenclature, beginning with the reasons for naming plants, the need for a standardized system of nomenclature, the problems with common names, etc. He then deals briefly with the fascinating history of the development of nomenclatural systems, beginning with the writings of Aristotle and Theophrastus, and moving through the systems of the Middle Ages (doctrine of signatures, etc.), to the binomial system established by Linnaeus and followed to this day. It is commendable that he has been able to include all of the most important developments in an interesting and readable fashion. Some background is also provided on the nature of the species problem in plants, and he puts the processes of taxonomic botany (and the name changes that are often required as a result of revisions) into perspective.

Two chapters are dedicated to discussions of the history and development of the *International Code of Botanical Nomenclature* and the *International Code of Nomenclature for Cultivated Plants*. These are complicated documents, and Gledhill has focussed on the most important points, avoiding the technical and often legalistic arguments that come into play in plant

nomenclature. Anyone interested in the technical details is referred to the Codes. There is also a very useful summary of the rules of Latin grammar as they relate to the formation of names. There are more detailed books available on the subject, but the account given in this book (well supplied with examples) covers the subject quite well.

The largest, and perhaps most useful, section in the book is the glossary. Here, the author lists a large number of Latin and latinized botanical names (mainly specific epithets, prefixes, and suffixes, but also some generic names). It is selective in that it includes names that are readily definable, descriptive, or have their basis in mythology. Many obscure, arbitrary, or undefinable names are excluded. There also seems to be a bias toward Eurasian geographical names, but most North American geographical epithets have obvious derivations, so this is not a serious omission.

I have only one complaint about this book. Scattered throughout the glossary are a series of illustrations that serve to define certain plant structures. The illustrations themselves are perfectly adequate, but there is no way to find out where they are without flipping through the pages (there is no list of figures in the table of contents). If a reader wished to determine the meaning of an epithet such as "peltatum", it would be a simple matter to check the alphabetical glossary, and there is a reference to Figure 5(d), but no page number is given (and the figure is not on the same page as the word "peltatum"). There are few typographical (14) or production errors (1) in the book, and its production features (hard cover, strong binding) should ensure a long shelf life. Other than the relatively minor points outlined above, the book is excellent, and fulfils its expressed purpose well.

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Wildflowers of the Canadian Rockies

By George W. Scotter and Hälle Flygare. 1986. Hurtig, Edmonton. xix + 170 pp., illus. Cloth \$29.95; paper \$19.95.

This book should not be confused with *Rocky Mountain Wildflowers* by A. E. Porsild, published in 1974 by the National Museums of Canada and Parks

Canada. That volume contained 257 reproductions of water colour paintings by Dagny Tande Lid.

The present volume contains a collection of over 260 excellent colour photographs of 228 species of flowering plants of the Rocky Mountain parks that are found in eastern British Columbia and western

Alberta. This is only a selection of the more than 1500 plant species found in the southern Rocky Mountains, but is certainly a selection of the most beautiful.

The species are organized by flower colour: green to white, yellow, pink-red-orange, and purple-blue. The pages of these four sections are all well marked by broad colour stripes on the outer margins. This is the only key to identify any of the species pictures. Users must then compare the plant they have found with the pictures in that section, and because the picture quality is so good, this should not be difficult.

Each species that is depicted is accompanied by an easily read descriptive paragraph which is headed by the common name or names (used in that part of the country), the scientific name, and the common name of the family. Distributions in the National Parks found in the Canadian Rocky Mountains are indicated by letters: Banff (B) Jasper (J), Kootenay (K), Waterton Lakes (W), and Yoho (Y). Distributions in provincial parks and wilderness areas can be judged by their proximity to these national parks. An indication is given of the type of habitat in which the various species may be found and interesting

comments are made on the uses to which some have been put.

A short introduction provides a description of the book, why it was written, and how to use it. The vegetation zones are depicted and described. There is a short glossary, line drawings depicting parts of typical flowers, a list of the families represented in the book, a list of selected references, and indices of common and scientific names.

Visitors to the Canadian Rockies will treasure this colourful publication as not only a key to what they may have seen as they passed through, but also as a memento of their trip through this magnificent part of our country. For those who have not yet travelled there, it is a view of things yet to be seen, and for those who may not go, a view of a part of nature's beauty from afar.

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Guide to the Vascular Plants of the Florida Panhandle

By Andre F. Clewell. 1985. University Presses of Florida, Gainesville. 605 pp., illus. \$30.00.

To someone from the northern part of the continent, the peninsula of the state of Florida looks like a panhandle. However, the panhandle of Florida is the narrow northern part of the state, composed of twenty-one counties, which lies east of Alabama and the Perdido River on the west and the Suwannee River on the east. The states of Alabama and Georgia lie to the north, and the southern shores are washed by the Gulf of Mexico. It is not a large area, measuring only 14 915 square miles or 38 628 square kilometers. The terrain is made up of a mosaic of pines, oaks, swamps, marshes, and bogs with hummock inclusions of mixed hardwoods. In this area over 2375 species are known to occur.

The bulk of this work comprises dichotomous keys to the families, genera, and species. These have largely been devised by the author to accommodate the species of the region, and appear to be quite adequate. Family and generic descriptions are provided, but only in the cases where there is a single species in a genus is there a detailed description of an individual species. Following the species keys are lists of the species in each genus, together with the common name, if any, habitats in which the species is found, and if of infrequent occurrence, a list of the counties from which the species is known. Time of flowering is given and some pertinent synonymy is provided. A

most useful feature is the inclusion of references to recent treatments in the scientific literature.

Introductory materials include a discussion of the panhandle area, short descriptions of the habitats, a glossary, and line drawings of leaf, inflorescence, flower, fruit and pubescence types. Indices of common and scientific names complete the work.

Floras such as this are usually out-of-date by the time they are published. Fortunately the author was able to include 15 species new to the Panhandle, as well as notes on some recently published taxonomic revisions in a section between the body of the text and the index. These taxa have been included in the index, so, although they are not keyed out, they are not lost.

This book is a useful contribution to the knowledge of a part of the state of Florida for which little has been written before. Those who use it, however, may find that it is best used in conjunction with other works that contain detailed species descriptions such as Radford et al.'s *Manual of the Vascular Flora of the Carolinas*, or even Small's *Manual of the Southeastern Flora*, although the latter is much out-of-date. Winter visitors from Canada and the northern United States will, for the most part, find themselves in the more southern peninsular Florida, and will thus find many species not included in this flora.

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Grass Genera of Western Canadian Cattle Rangelands

By S. G. Aiken and S. J. Darbyshire. 1983. Research Branch Monograph 29. Agriculture Canada, Ottawa. 173 pp., illus. \$9.00.

The authors intend this book to be a step along the road to a monograph of the species of western Canadian rangeland grasses. If this *step* is any indication of the quality and utility of the final product, we are in for a real treat.

The area treated by the book encompasses all of the grassland and lightly wooded areas of western Canada where livestock are grazed, thus including virtually all agriculturally developed lands and major population centres. It updates the nomenclature and generic taxonomy of western grasses from their treatment in a number of now-dated manuals and studies. It also provides an original generic key that is unusually detailed while remaining readable and effective. This key was developed with the assistance of a computer-generated model that accommodates the assessment of 92 characters for each genus. The ultimate form of the key, however, was fixed by the subjective modification of the computer model based on the authors' personal experience with grass identification. They hoped in this way that it would be an accurate tool that allows readers to identify material even if one or two of the traditionally critical characters are not available. In my experience, it seems to have achieved that goal admirably.

The 11-page section on grass morphology is a particular high point of the book for me. It describes the form, function, and taxonomic significance of a wide variety of morphological features, with reference to a distinct illustration or illustrations. This section provides an excellent understanding of basic grass structures and their importance. That provides tremendous help in comprehending the technical discussion in this and other grass studies.

Each genus is treated in a similar manner. A detailed technical description is provided, a list of the Canadian species is given, and taxonomic notes are

made (as required). Pertinent literature references for that genus complete the treatment — a very helpful feature for further study by the reader. For particularly difficult groups, tables are provided that list the values of various important identification features (e.g. *Glyceria*, *Puccinellia* and *Torreyochloa* on page 56).

All major genera are nicely illustrated by a pen and ink sketch of a typical species that includes the critical morphological features. These illustrations were skillfully executed by S. E. Aiken (son of the senior author) and the late Anne Hanes. They complement the text very well.

There seem to be few factual or production errors or omissions in the book. The type registration on page 85 of my copy is slightly off, making for strained reading. The type face is otherwise clear and readable.

For some unclear reason, the list of references at the end of the book is incomplete. A quick glance revealed a number of references cited in the generic discussions but omitted from the overall list (e.g. Gould and Clarke's important *Dichanthelium* paper). The authors should have either entitled this "Selected References" or, better yet, have included all citations. This would save the reader a lot of skipping back and forth. That, however, is the only significant fault I found.

One need not be concerned just with the grasses of western Canada to benefit from this nicely produced, attractive paperback that is a steal at the price. I highly recommend it to anyone interested in grass identification in southern Canada and the northern United States. It is an excellent piece of work and certainly constitutes an important addition to Canadian grass literature.

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ENVIRONMENT

Keys to the Fauna and Flora of Minas Basin

By Joan E. C. Bromley and J. Sherman Bleakney. 1985. National Research Council of Canada No. 24119. Acadia University Institute, Wolfville, Nova Scotia. xi + 336 pp., illus. \$19.95 + \$3.00 shipping.

This manual provides illustrated keys for the identification of 405 species of larger invertebrate

animals and fishes, and 130 plant species of Minas Basin, a unique tidal marine environment at the head of the Bay of Fundy in eastern Canada. The chief compilers of this much-needed guide have enlisted the help of several research associates, students, and specialists external to Acadia University to

encompass the major groups of benthic and pelagic groups of organisms commonly encountered on the bottom, along shore, and in the upper brackish estuaries of this immense tidal basin. The keys are essentially multiple-character in format, and the accompanying illustrations are clear and competently executed, many by artist Bromley; in some cases they are reproduced (with permission) from pertinent major reference works. Especially well done are the line illustrations for the 24 species of nudibranch mollusks recorded from eastern Canada and northern New England.

In a work of this size and scope, some errors and omissions are perhaps inevitable, partly because of the long "gestation time" of the book (commenced in 1979), all sections of which were apparently not uniformly "updated". Thus, within the Mollusca, the common salt marsh snails *Melampus bidentatus* and *Ovatella myosotis* have not been included, whereas the quahog, *Mercenaria mercenaria*, which does not occur naturally in the Basin, is illustrated. The polychaete taxonomy is especially out of date, the keys somewhat cumbersome to use, and the common species too sparsely illustrated.

Within the Crustacea, the recorded regional haustoriid amphipod is *Acanthohaustorius spinosus* (*A. millsi* is more southern and *Haustorius canadensis* occurs in the Gulf of St. Lawrence); the sandhopper, *Talorchestia longicornis* (not listed) is common on the sand beach at Kingsport; *Gammarus annulatus* is known from Sable Island but not from the Basin, and the genera *Erichthonius* and *Gammarellus* have recently been correctly placed in families Ischyroceridae and Gammarellidae, respectively. The oceanic goose barnacle *Lepas* is a highly unlikely drifter into the region. The authors have treated some pelagic or planktonic invertebrate groups, such as the copepods, ctenophores, and squids, but did not include the large

pelagic medusae, *Aurelia* and *Cyanea*, which commonly wash up on the beaches. However, the plastic "loose-leaf" binding permits easy revision and updating of the contents. In future, the authors may wish to replace some of the taxonomic descriptive material (not really necessary because of the generally fine illustrations and keys) with brief information on the ecology, life history, behaviour and distribution on the species, and thus aid the user in locating the animal or plant species in the field. Despite the excellence of the illustrations of microstructure, the user would appreciate whole-organism sketches of the bryozoans (e.g. *Flustra*) as well. Glossaries of terms in the larger and more important groups would have been helpful.

This set of illustrated keys is really the first published comprehensive guide to the macro maritime biota of eastern Canada. Although it is designed to treat mainly the biota of Minas Basin, the guide applies reasonably well to most other boreal and temperate coastal marine subregions from the Gulf of St. Lawrence and Newfoundland to northern New England. The authors might have made greater use of existing regional reference material, especially the NOAA Technical Report series of the past decade on the Marine Flora and Fauna of the Northeastern United States. Students, fisheries biologists, marine ecologists, and informed beach-combers are likely to find this book invaluable and a standard regional reference work for some time to come. The authors and collaborators have made a good and useful start in fulfilling this important need, at a most reasonable price.

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The Background of Ecology: Concept and Theory

By Robert P. McIntosh. 1985. Cambridge University Press, Cambridge. xiii + 383 pp. U.S. \$39.50.

If science were simply the collection of facts, there would be no need to worry about its history. But science is not like that, least of all ecology. There is no such thing as a "simple fact", and we cannot really understand the ideas of today without understanding the context in which they developed.

Parts of the history of ecology have been documented in articles by F. N. Egerton, McIntosh himself, and others. Donald Worster's book, *Nature's Economy*, is subtitled "The Roots of Ecology" but is

in fact a history of environmental awareness and activism, not of science. The present work, then, is really the first book to tackle the history of ecology as a scientific discipline, at least in its Anglo-American manifestation.

The history is fascinating. Philosophers have discussed the relationship between humankind and nature for at least three millennia, so it is not difficult to find traces of ecology in the oldest documents. However, McIntosh makes a good case for ecology crystallizing as a self-conscious scientific discipline quite suddenly in the last decades of the nineteenth century. Since that time it has had a querulous,

fragmented history, highlighted by multiple re-inventions of the wheel (or of the ecological equivalent of the perpetual motion machine). More recently the name "ecology" has been linked with salvation of the world, revolutions in moral standards, and other, more bizarre causes. The historical perspective is clearly called for to help us understand how we got into this predicament.

McIntosh proceeds by exploring first several separate roots of modern ecology: limnology, marine ecology, terrestrial animal ecology (populations), and terrestrial plant ecology (communities). He then works forward in time to more recent phenomena such as systems theory, "big ecology" (an excellent discussion of IBP and its failures), and the environmental movement. These pieces overlap considerably, and since his descriptions are written more like self-contained journal articles than chapters of a book, there is some repetition. This is particularly noticeable with the topic of community, his specialty, which shows up many times. Since the story of Clements, Gleason, and friends is one of the most familiar historical episodes in ecology, the repetition is a bit bothersome. McIntosh also has the questionable habit, for a historian, of quoting extensively from secondary sources, a University of Toronto thesis by S. E. Kingsland, for example. Some of his references are almost impossible to track down as a result. On the other hand, his writing is full of humour, albeit humour so dry as to be almost invisible in short passages. He is helped in this respect by his subjects, the ecologists of the last hundred years, who, as a group, were more successful with their one-liners than with their theories.

From out of the thousands of details patterns emerge. Ecology has had a single dominant meta-theory: the "balance of nature", with its aliases of superorganism, equilibrium, stability, homeostasis,

and so on. Yet, as Charles Elton said bluntly over fifty years ago, and as most serious ecologists have known full well, "the balance of nature does not exist." It is this confusion of paradigms that makes the superorganism so unsatisfactory and yet so indestructible as a theory. As McIntosh points out, "superorganisms are not easily killed by mere logic." It is the same paradigm confusion that causes the tension between ecology and environmentalism. Humans change the world, but does this make the species "unnatural"?

On the second page we are told that "ecology was not, and is not, a predictive science". This rather depressing outlook is supported repeatedly through the book. And yet, there is a missing element, an element that does not appear until the second last page. It is the experienced practitioners, the individual practising ecologists who work successfully to understand parts of the world. How they manage to do so, despite the theoretical uncertainties that surround them, is unclear. It would seem to be related to the fact that there is much more to theory than testable hypotheses and falsification, and that ecologists have had many useful organizing concepts if not predictive theories. This is a fine problem for philosophers of science as they move beyond physics. What is clear, however, is that the theoretical murk is commonly thicker than necessary because of a failure to learn from the past. With the arrival of this readable and sophisticated volume, any serious ecologist who continues to ignore the past has no excuse for neglecting a responsibility, and a pleasure.

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Environmental Groups in Politics

By P. Lowe and J. Goyder. 1983. George Allen and Unwin, Boston. 208 pp., illus. Cloth U.S. \$30.00; paper U.S. \$13.95.

The environmental movement has grown over the last century to become a prominent sociopolitical phenomenon. Lowe and Goyder report that in Britain there are nearly one hundred national environmental groups and several thousand local ones. About 10 percent of the British adult population belongs to an environmental group. The influence of the environmental movement is not what one would expect given its size, which as a whole is larger than any British

political party or trade union. Since the environmental movement is composed of groups which differ in social characteristics, the values they express, their historical origins, and subsequent pattern of development, their influence also varies. It is the diversity of the environmental movement and the impact on society and political decision-making that the authors focus on.

Two main themes are developed: the internal organization of environmental groups, and their external relations with social and political systems. The former is assessed in terms of how unity and internal authority are maintained, support engen-

dered, resources allocated, and goals set. External relations are viewed in terms of how groups relate to society, the political system, and changes in social values and structure. Information is drawn from a comprehensive literature review and questionnaire surveys of 77 environmental groups.

The book is organized into two parts. The first part is a synthesis of information concerning internal and external relations of environmental groups and is organized into several themes. Discussions of such general characteristics of the environmental movement as the relationship of the groups to the attentive public, historic development of the environmental movement, values of environmentalism, roots of environmental concern, and influence of economic growth are presented. The organization of environmental groups is discussed in terms of their aims, membership, income, staff and expertise, internal decision-making and authority, and organizational effectiveness. The movement's relationship to national and local politics is discussed in terms of political resources, relations with and access to government and the media, structure of the

lobby, and tactics of the various groups. The second part deals with much of the same themes but concentrates on the following groups: The Henley Society, Friends of the Earth, The National Trust, The Royal Society for Nature Conservation, and The European Environmental Bureau.

The book is written very clearly and contains little jargon. It is important because of the overview of the environmental movement and the specific discussions of individual groups. I recommend it to persons involved in environmental groups as well as government organizations. Although it is largely a sociologic assessment of the environmental movement, it is applicable to resource managers involved with a more scientific subject matter because even such projects occur within a sociopolitical context and can benefit from an understanding of this relationship.

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The Fight to Save the Redwoods: A History of Environmental Reform 1917-1978

By S. R. Schrepfer. 1983. University of Wisconsin Press, Madison. 338 pp.

Susan Schrepfer's book is a very thorough and detailed account of the social and political interactions resulting from the efforts to preserve the redwoods in California. She casts these efforts into the greater contexts of the ideology of individuals and interest groups, the environmental movement, and the sociopolitical climate of each era. She distinguishes three periods of environmental reform based largely on the nature and intensity of citizen activism. During the first period from the 1890s through the 1920s activism was strong but generally moderate; from the 1930s through the 1940s activism was relatively quiet; but from the mid 1950s "the anger and influence of the participants burst forth, to flourish in the 1960s" when "militants channelled their hostility toward developers and industrialists into environmental litigation and legislative advocacy." Within these periods, the author provides a comparative analysis of the development, tactics, leadership, membership, financial resources, and ideological position of the Save-the-Redwoods League and the Sierra Club. The following is an indication of the subject matter that the author discusses.

Schrepfer traces the initiation of environmental awareness of the growth and influence of the natural

sciences which allowed explanation of human-environmental relationships by reference to natural laws, not theology. Concurrently, forestry schools were established in Europe and from these, themes of wise resource use emanated. This sector of the conservation movement was bound by strong professional loyalties. Although the ideologic orientation of the conservationists differed from that of the preservationists, at first their goals and actions complemented each other. Schrepfer indicates the preservation movement blended scientific and romantic views which contrasted with the conservationist's mechanistic, empirical attitude toward nature. The preservationist's view perhaps reflected a reactionary mood, a view that idealized moral life, sought to restore 19th century morality, and advocated nature as an antidote to industrialization and urbanization. Nature was a source of inspiration for those gentleman naturalists seeking the exotic and mysterious.

Schrepfer shows that the essence of the preservation movement at the turn of the century rested primarily on professionalism. Because of their mobility, education, and social position, the League's leaders acquired a broad geographic perspective which was previously found only among the wealthy. The League's leaders "were part of a middle class that had the time, economic security, and facilities with which

to look beyond the day's work and try to locate themselves within a national system." Yet the very economic system that provided the opportunity to experience nature and discover its value also led to the modification or destruction of nature.

The author discusses the special value that the redwoods represented to the professional scientists and naturalists of the late 18th and early 19th centuries. Their perception of these trees transcended the mere facts of their magnificence. In them, preservationists saw a powerful aesthetic experience and evidence of the new world view inspired by evolutionary theory. This discovery and experience of nature was concurrent with the rapid transformation of wilderness in the United States. Concern for the redwoods grew not only because they were largely held in private ownership and the demand for wood products dramatically increased with new technological developments and transportation corridors but also because of prevalent attitudes toward the trees and an aversion to wilderness. There was a belief that the trees held "phoenix-like powers of reproduction . . . each giant was replaced by Herculean infants that would be ready for the saw in 20 years". There was also a belief that the wilderness would produce a hardy race and the lumber jack was symbolic of this view.

The League initiated the preservation of the redwoods by buying tracts of land of high scenic quality from lumbermen. Their success rested mainly on the favourable sentiments of philanthropists whose activity peaked in 1929. Later the Sierra Club became involved in the issue but the tactics of each group differed considerably and their successes varied as the sociopolitical climate changed. The League's leaders

believed that they needed to balance their desires to save the redwoods with their strong respect for the rights of private property and the needs of industry. Schrepfer shows that this position was very effective in the first two periods but gave way to the more militant position of the Sierra Club during the last period. Contrary to the League, the Sierra Club rejected the notions of design in nature and purposiveness in evolution, distrusted and challenged authority and established values of government and industry, and tended to resolve disputes more through the courts than by compromise.

The book is well worth reading by anyone involved in the environmental professions or interest groups because it provides an integration of scientific, ideological and sociopolitical facets of this environmental problem. As such it provides a more complete understanding than would separate accounts of each topic. Those persons not particularly interested in the detailed sociopolitical interactions may want to begin with Chapter 12, which provides a summary of these, and later skim over Chapters 2, 5, 8, 9, 10 and 11 which are very detailed. Chapters 1, 3, 4, 6 and 7 may be of more interest to the general reader and contain discussions of the early preservation movement, ideology of reform, role of parks, evolution and ecology and impact of industry on redwood ecosystems, respectively. The reader will also find the 72 pages of notes very useful.

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The State of the World's Parks: An International Assessment for Resource Management, Policy and Research

By Gary E. Machlis and David L. Turner. 1985. Westview Press, Boulder, Colorado. 131 pp., illus. U.S. \$28.85.

Once a park is created, we often fail to conceptualize the park and the integrity of the park's ecosystem in the context of the influences of the outside world. In addition, we tend to fall into a state of complacency about the status and management of the park environment. For example, many people often assume that the designation of a park automatically eliminates any threats to the environment within the park. This is, of course, an incorrect assumption.

This book describes a study of 100 of the world's parks, located within 49 countries. The authors strive

to answer two basic questions: what are the threats to national parks worldwide, and what can be done about these threats? The book is composed of five chapters. Chapter 1 provides an overview of the study, defines national parks and the concept of threats, and identifies a number of important assumptions about man and nature.

Chapter 2 concentrates on the origins of threats to parks. The authors review global trends that result in increasing ecological change, which may be significant sources of threats to parks; the issues relating to the cultural adaptation of the national park concept; ecological management in national parks; and the question of park boundaries. The authors examine the evolution of the management of parks

from areas once perceived as static, self-maintaining entities to dynamic ecosystems (or parts of ecosystems) requiring the implementation of effective management programs. This evolution was particularly evident during the 1960s because of an expanding scientific knowledge of ecology, increasing numbers of environmental and socio-economic impacts, and increasing management experience. The authors feel that a significant limitation in the design of parks relates to the identification and establishment of park boundaries. For example, many parks do not encompass the habitat required to sustain complete faunal assemblages.

Chapter 3 focuses on the relationship between human beings and their environment. The fundamental conclusion from this review is that human ecosystems are dynamic and adaptive, and that parks should be managed in the context of these two major factors.

Chapter 4 describes the results of an extensive international mail survey, and provides a "... profile of the perils parks face around the world". The two objectives of the research were:

1. "To identify the sources, extent, and effects of threats to the resources of a selected international sample of national parks".
2. "To examine whether the identified threats vary among parks of different sizes, in different biomes, in countries at different stages of development, and affiliated or not with special management programs".

The chapter is comprised of a number of statistical tables describing the results of the survey. The limitations of the survey are explicitly reviewed, and a profile of the respondents is provided. The results of the survey are discussed according to: the diversity of threats to parks, suspected vs. documented threats, threatened subsystems, man and nature as causes of

threats, and the location of threats to parks. In addition, the results are discussed in the context of park size, biome type, stage of economic development, and affiliation with special management programs.

The conclusions and recommendations are outlined in Chapter 5. The authors identify eight conclusions: substantial and diverse threats confront the natural resources of national parks worldwide, many threats are not well documented, although man may be the principal cause of threats to parks, nature plays an important role as well; threats are located both within and outside park boundaries; most reported threats are localized within park areas; animal life and vegetation subsystems are most often affected; many threats are common to parks worldwide, but the frequency of their occurrence differs; and the characteristics of reported threats differ (sometimes significantly) among parks by size, biome type, stage of economic development, and management program. Each conclusion is discussed in some detail. The recommendations address the role of international organizations in managing threats to parks, strategies for national agencies and parks, and critical research needs.

The book contains two appendices describing notes on the research methodology and categorization of the sample by key study variables, and a literature cited section. I recommend the book to resource managers charged with the responsibility of managing parks or other types of special areas.

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MISCELLANEOUS

Hamilton Mack Laing: Hunter-Naturalist

By Richard Mackie. 1986. Sono Nis Press, Victoria. 234 pp., illus. \$19.95.

The death of ninety-nine-year-old Hamilton Mack Laing just four years ago in Comox, British Columbia, marked the end of an era. Mack, as he was commonly known, was the last of Canada's Victorian naturalists who used the gun and skinning knife to make large collections of faunal life. He was also the last living link to a generation of prominent Canadian naturalists—men such as Percy Taverner, Hoyes Lloyd, J. H. Fleming, and Rudolph Anderson. He

was also probably one of the last of the "practical naturalists" who believed that predators should be mercilessly exterminated and that man could best control nature.

Richard Mackie's *Hamilton Mack Laing: Hunter-Naturalist* is the new biography of this unusual figure. Born in 1883 in Ontario but raised on a Manitoba farm, Laing regarded himself as a product of the Canadian frontier — a combination hunter-naturalist. He took an early interest in the natural life of rural Manitoba and came to know

intimately the life cycle and habits of many animals. He also proudly served as game warden for the family farm and dutifully disposed of unwelcome pests and predators with a vengeance. He never lost this curious love-hate relationship with nature; indeed, he was known to blast away at undesirable birds at his feeder outside his retirement home, Shakesides.

In 1901, when Mack became a school teacher, he started to keep a nature diary, make sketches and collect specimens. He also embarked on a prolific writing career, never reaching the heights of his mentors Ernest Thompson Seton and Charles G. D. Roberts, but nevertheless noted for his realistic and lucid style. In 1911, a restless Mack left teaching to take art courses in Brooklyn, New York, and then served as a gunnery instructor in Ontario during the latter years of the Great War. During this period, he continued to write his carefully-crafted nature stories for a number of popular magazines. He also made the acquaintance of Taverner, Fleming, and Lloyd, who immediately recognized Mack's potential and tried to secure him a suitable natural history posting. A position never materialized, but working out of his nut farm at Comox during the 1920s and 1930s, Mack served as a freelance collector for the National Museum of Canada and other scientific institutions and individuals. It was during these years that Mack acquired his reputation as an indefatigable, competitive field worker who could be counted on for large and richly varied collections. He also emerged as

one of the leading defenders of the wholesale destruction of predators and took great delight in chastising the emerging generation of so-called "opera glass" naturalists. These extremely active years came to an end in 1944, however, when he sold his farm after the death of his wife and retired to Shakesides for his remaining years.

Mackie has put together his book in a curious way. The first two-thirds of the biography is essentially a narrative account of Mack's life up until 1944. The remainder is devoted to an assessment of his hunter/naturalist outlook, his writing, and his character. It would have made for better reading if this analytical material could have been integrated into the main body of the book. It would also have been valuable if the author could have said more about Mack's scientific contributions, as well as placed his work in the context of the state of Canadian natural history at the time. These comments aside, Mackie has made good use of Mack's voluminous correspondence, in particular the Taverner letters. He has effectively captured the determined, chauvinistic, outspoken, at times crusty, character of Mack Laing and in doing so, demonstrated why he was something of a legend in his own time.

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Gosse's Jamaica 1844-45

Edited by David B. Stewart. 1984. Institute of Jamaica Publications, 2A Sutherland Road, Kingston 10, Jamaica. \$70 Jamaican.

Philip Henry Gosse was at the peak of his powers during his 19-month stay in Jamaica in 1844-1846, and is deservedly honored as "the father of Jamaican Ornithology." His *Birds of Jamaica* in 1847 was the ornithological classic of the English speaking Caribbean and as David Lack said, "was far ahead of its time and remained one of the best bird books on any part of the world for at least half a century." His *A Naturalist's Sojourn in Jamaica* in 1851 "combines a broader account of the island's natural history with a fascinating picture of the country and its people."

Stewart, the Head of Obstetrics and Gynecology at the University College of the West Indies from 1953 through 1970, was a member of the local Gosse Bird Club. He has performed a valuable service in choosing selected excerpts from Gosse's two Jamaican books and his *Illustrations of the Birds of Jamaica*, 16 pages of which are reproduced, eight in full colour. Throughout the book Stewart has provided succinct, unobtrusive and helpful explanations and modern

names, based on James Bond's *Birds of the West Indies* (the book went to press before the sixth AOU Checklist appeared).

Gosse was not only a talented, all-round naturalist but a remarkably astute observer of bird behaviour. He described two new genera, *Geotrygon* and *Tachornis*, and 16 new taxa, eight of which have maintained their priority as full species and one as subspecies.

Gosse is of interest to Canadians because he spent 11 years in Newfoundland and then farmed for three years in the eastern townships of Quebec. His first book, entitled *The Canadian Naturalist*, launched one of the most successful natural history writing careers of the 19th century.

As Lynn Barber notes, Gosse had a "charm, a joie de vivre and a sense of poetry . . . and a really astonishing ability to describe . . . things vividly and dramatically." Any naturalist planning a trip to Jamaica should read this book first.

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NEW TITLES

Zoology

†**Atlas of the breeding birds of Ontario.** 1987. Edited by M. D. Cadman, P. F. J. Eagles, and F. M. Helleiner. University of Waterloo Press, Waterloo. 608 pp., illus. \$53.50.

The behavior of teleost fishes. 1986. Edited by Tony J. Pitcher. Johns Hopkins University Press, Baltimore. xvi + 553 pp., illus. U.S.\$57.50.

Bioenergetics of wild herbivores. 1985. Edited by Robert J. Hudson and Robert G. White. CRC Press, Boca Raton, Florida. 328 pp. U.S.\$169 in U. S. A.; U.S.\$194 elsewhere.

Birding on the Navajo and Hopi reservations. 1986. By Brad Jacobs. Jacobs, Sycamore, Missouri. Illus. U.S. \$7.95 + U.S.\$0.75 postage.

***The birds of Africa, volume 2.** 1986. Edited by Emil K. Urban, C. Hilary Fry, and Stuart Keith. Academic Press, London. 552 pp., illus. + plates. £65 (U.S.\$99).

***The birds of the Creston Valley and southeastern British Columbia.** 1986. By Robert W. Butler, Brian G. Stushnoff, and Edward McMackin. Canadian Wildlife Service Occasional Paper No. 58. Environment Canada, Ottawa. 37 pp., illus.

Birds of the Pacific slope. 1986. By Andrew Jackson Grayson. Arion Press, San Francisco. 500 pp. + 156 plates. Limited edition of 400 sets. U.S.\$4500.

Birds of the Rocky Mountains: with particular reference to national parks in the Northern Rocky Mountain Region. 1986. By Paul A. Johnsgard. c500 pp., illus. Cloth U.S.\$39.50; paper U.S.\$16.95.

The last extinction. 1986. Edited by Les Kaufman and Ken Mallory. MIT Press, Cambridge. Illus. U.S.\$16.95.

Building models for conservation and wildlife management. 1986. By A. M. Starfield and A. L. Bleloch. Macmillan, New York. xiv + 253 pp., illus. U.S.\$34.95.

***The breeding bird survey: its first fifteen years, 1965-1979.** 1986. By Chandler S. Robbins, Danny Bystrak, and Paul H. Geissler. Resource Publication 157. U.S. Fish and Wildlife Service, Washington.

The butterflies of Costa Rica and their natural history: Papilionidae, Pieridae, Nymphalidae. 1986. By Philip J. DeVries. Princeton University Press, Princeton. c390 pp., illus. Cloth U.S.\$69; paper U.S.\$26.

***Butterflies of North America: a natural history and field guide.** 1986. Stanford University Press, Stanford. U.S.\$49.50.

The chimpanzees of Gombe: patterns of behavior. 1986. By Jane Goodall. Belknap (Harvard University Press), Cambridge. xiv + 674 pp., illus. + plates. U.S.\$30.

CRC handbook of animal diversity. 1986. By Richard Blackwelder and George S. Garoian. CRC Press, Boca Raton, Florida. 568 pp. U.S.\$165 in U.S.A.; U.S.\$190 elsewhere.

Culture of nonsalmonid freshwater fishes. 1986. By Robert R. Stickney. CRC Press, Boca Raton, Florida. 216 pp. U.S.\$93 in U.S.A.; U.S.\$107 elsewhere.

Cutthroat: native trout of the west. 1986. By Patrick C. Trotter. Colorado Associated University Press, Boulder. c300 pp., illus. U.S.\$25.

Dolphin cognition and behavior: a comparative approach. 1986. Edited by Ronald J. Schusterman, Jeanette A. Thomas, and Forrest G. Wood. Erlbaum, Hillsdale, New Jersey. xviii + 393 pp., illus. Cloth U.S.\$49.95; paper U.S.\$24.95.

Ecology and evolution of Darwin's finches. 1986. By Peter R. Grant. Princeton University Press, Princeton. c464 pp., illus. Cloth U.S.\$63.50; paper U.S.\$26.

Ecology and natural history of desert lizards: analysis of the ecological niche and community structure. 1986. By Eric R. Pianka. Princeton University Press, Princeton. 222 pp., illus. Cloth U.S.\$52; paper U.S.\$23.

†**Eider ducks in Canada.** 1986. Edited by Austin Reed. Canadian Wildlife Service Service Report No. 47. Environment Canada, Ottawa. 177 pp., illus. \$19.50 in Canada; \$23.40 elsewhere.

***A field guide to atlantic coast fishes of North America.** 1986. By C. Richard Robins and G. Carleton Ray. Houghton Mifflin, Boston. xi + 354 pp. + plates. U.S. \$14.95.

A field guide to the birds of Hawaii and the tropical Pacific. 1987. By H. Douglas Pratt, Phillip L. Bruner, and Delwyn G. Berrett. Princeton University Press, Princeton. c640 pp., illus. Cloth U.S.\$57.50; paper U.S.\$23.

Foraging theory. 1986. By David W. Stephens and John R. Krebs. Princeton University Press, Princeton. c256 pp., illus. Cloth U.S.\$46; paper U.S.\$16.75.

***A functional biology of sticklebacks.** 1984. By R. J. Wootton. University of California Press, Los Angeles. 265 pp., illus. U.S.\$29.75.

†**Harrier, hawk of the marches: the hawk that is ruled by a mouse.** 1986. By Frances Hamerstrom. Smithsonian

- Institution Press, Washington. 171 pp., illus. Cloth U.S.\$24.95; paper U.S.\$10.95.
- Island biogeography of mammals.** 1986. Edited by L. R. Heaney and B. D. Patterson. Academic Press, New York. 256 pp. U.S.\$22.50.
- Mammal evolution: an illustrated guide.** 1986. By R. J. G. Savage and M. R. Long. Facts on File, New York. 264 pp., illus. U.S.\$35.
- †**Mammals of Arizona.** 1986. By Donald F. Hoffmeister. University of Arizona Press, Tucson. xx + 602 pp., illus. U.S.\$49.95.
- ***Les oiseaux des régions forestières du nord-est du Gabon, volume 1: écologie et comportement des espèces.** 1986. Par A. Brosset et C. Erard. Société National de Protection de la Nature, Paris. 297 pp., illus. 200 FF in France, 250 FF elsewhere.
- Primates: the road to self-sustaining populations.** 1986. Edited by K. Benirschke. Proceedings of a conference, San Diego, June, 1985. Springer-Verlag, New York. cl120 pp., illus. U.S.\$79.
- †**Red fox: the catlike canine.** 1986. By J. David Henry. Smithsonian Institution Press, Washington. 174 pp., illus. U.S.\$22.50.
- Revised atlas of eastern Canadian seabirds: 1, shipboard surveys.** 1986. By R. G. B. Brown. Canadian Wildlife Survey, Ottawa. 111 pp., illus. \$8.
- Snake versus man: a guide to dangerous and common harmless snakes of southern Africa.** 1985. By Johan Marais. U.S. distributor ISBS, Portland, Oregon. x + 102 pp., illus. U.S.\$7.95.
- †**Spider: a story of a predator and its prey.** 1986. By Dick Jones. Facts on File, New York. 64 pp., illus. U.S.\$12.95.
- †**A systematic study of the nearctic larvae of the *Hydropsyche morosa* group (Trichoptera: Hydropsychidae).** 1986. By Patricia W. Scheffer and Glenn B. Wiggins. Life Sciences Miscellaneous Publications. Royal Ontario Museum, Toronto. 94 pp., illus. \$14.25.
- ***Wildlife 2000: modeling habitat relationships of terrestrial vertebrates.** 1986. Edited by Jared Verner, Michael L. Morrison, and C. John Ralph. University of Wisconsin Press, Madison. xxv + 470 pp., illus. U.S.\$17.50.
- Botany**
- The bamboos of the world: a preliminary study of the names and distribution of herbaceous and woody bamboos (Bambusoideae Nees vs. Esenb.): bibliography.** 1986. By D. Ohrnberger and J. Goerrings. Koeltz Scientific, Koenigstein, West Germany. 152 pp. 60 DM.
- Biological monitoring of environmental contaminants (plants).** 1986. By M. A. S. Burton. University of London, London. xii + 247 pp., illus. U.S.\$30.
- ***Biology of lichenized fungi.** 1984. By James Lawrey. Praeger (Greenwood Press, Westport, Connecticut). x + 480 pp., illus.
- The botany and natural history of Panama/la botanica e historia natural de Panama.** 1985. Edited by William G. D'Arcy and Mireya D. Correa A. Koeltz Scientific, Koenigstein, West Germany. xx + 454 pp., illus. 150 DM.
- The cactus primer.** 1986. By Arthur C. Gibson and Park S. Nobel. Harvard University Press, Cambridge. x + 286 pp., illus. U.S.\$39.95.
- ***Flora of New Brunswick.** 1986. By Harold R. Hinds. Available from Author, University of New Brunswick, Fredericton. 692 pp., illus. + maps. \$30.
- ***Flora of the Great Plains.** 1986. By the Great Plains Floral Association. University Press of Kansas, Lawrence. 1408 pp., illus. U.S.\$55.
- Forest site and productivity.** 1986. Edited by S. P. Gessel. Koeltz Scientific, Koenigstein, West Germany. 548 pp. 140 DM.
- Gardens of North America and Hawaii: a traveller's guide.** 1985. By Irene and Walter Jacob. Koeltz Scientific, Koenigstein, West Germany. 68 DM.
- List and index of literature related to plant taxonomy and phytogeography of Japan published in 1973 through 1982.** 1985. Edited by Hiroo Kanai. Koeltz Scientific, Koenigstein, West Germany. xii + 602 pp. 390 DM.
- ***Native and cultivated conifers of northeastern North America.** 1986. By Edward A. Cope. Cornell University Press, Ithaca. Cloth U.S.\$39.95; paper U.S.\$17.95.
- Orchid genera illustrated.** 1986. By Tom and Marion Sheehan. Reprint of 1979 edition. Comstock (Cornell University Press), Ithaca. 207 pp., illus. U.S. \$14.95.
- Orchids of Ontario: an illustrated guide.** 1986 By R. E. Whiting and P. M. Catling. Cana Coll Foundation (Nature Canada Bookshop, Ottawa). xi + 169 pp., illus. \$12.95.
- Plant community ecology: papers in honor of Robert H. Whittaker.** 1985. Edited by R. K. Peer. Junk (U.S. distributor Kluwer, Hingham, Massachusetts).
- Vegetation dynamics in temperate lowland primeval forests: ecological studies in Biolowieza Forest.** 1986. By J. B. Falinski. Koeltz Scientific, Koenigstein, West Germany. 548 pp. 400 DM.

Environment

Acid deposition and the acidification of soils and waters. 1986. By J. O. Reuss and D. W. Johnson. Springer-Verlag, New York. viii + 119 pp., illus. U.S.\$36.

Advances in marine biology, volume 23. 1986. Edited by J. H. S. Blaxter and A. J. Southward. Academic Press, New York. 388 pp. U.S.\$76.

Biotechnology risk assessment: issues and methods for environmental introductions. 1986. Edited by J. R. Fiksel and V. T. Covello. Pergamon Press, Elmsford, New York. 160 pp., illus. U.S.\$29.60.

British Columbia's coast: the Canadian inside passage. 1986. By the Alaskan Geographic Society, Anchorage. 200 pp., illus. U.S.\$14.95 plus U.S.\$1 postage.

***The concise natural history of New Zealand.** 1986. By Harriet Fleet. Heinemann (U.S. distributor ISBS, Portland, Oregon). 275 pp., illus. U.S.\$19.95.

Conservation biology: the science of scarcity and diversity. 1986. Edited by Michael E. Soule. Sinauer, Sunderland, Massachusetts. 480 pp., illus. Cloth U.S.\$46.50; paper U.S.\$27.

Conservation of tidal marshes. 1986. By Franklin C. Daiber. Van Nostrand Reinhold, New York. x + 341 pp., illus. U.S.\$39.95.

†**Ecology: individuals, populations, and communities.** 1986. By Michael Begon, John L. Harper, and Colin R. Townsend. Sinauer, Sunderland, Massachusetts. xii + 876 pp., illus.

The ecology of the forests and woodlands of South Australia. 1986. Edited by H. R. Wallace. Government Printing Division, Adelaide. 291 pp., illus. + plates. U.S.\$13.20.

†**Environment assessment in Canada: directory of university teaching and research, 1985-1986.** 1986. Edited by Ann Simpson and Lewis Yaeger. Federal Environmental Assessment Office, Hull. 145 pp.

Environmental ethics: philosophical and policy perspectives. 1986. Edited by Philip Hanson. Simon Fraser University, Burnaby. 199 pp. \$12.

Environmental impact assessment, technology assessment, and risk analysis: contributions from the psychological and decision sciences. 1985. Edited by Vincent T. Covello et al. Springer-Verlag, New York. x + 1069 pp., illus. U.S.\$127.50.

Environmental impacts of coal mining and utilization. 1986. Edited by M. J. Chadwick, H. H. Highton, and N. Lindman. Pergamon Press, Elmsford, New York. 450 pp., illus. U.S.\$82.50.

Estuarine ecosystems. 1986. By George A. Knox. CRC Press, Boca Raton, Florida. 320 pp. U.S.\$99.50 in U.S.A.; U.S.\$115 elsewhere.

Estuarine variability. 1986. Edited by Douglas A. Wolfe. Academic Press, New York. 502 pp. U.S. \$42.50.

Forest ecosystems in the Alaskan taiga: a synthesis of structure and function. 1986. Edited by K. vanCleve, F. S. Chaplin, and A. Oth. Koeltz Scientific, Koenigstein, West Germany. Illus.

†**Handbook of nature study.** 1986. By Anna Botsford Comstock. Comstock, New edition of 1911 publication (Cornell University), Ithaca. xii + 887 pp., illus. Cloth U.S.\$49.50; paper U.S.\$19.50.

†**A hierarchical concept of ecosystems.** 1986. By R. V. O'Neill, D. L. DeAngelis, J. B. Waide, and T. F. H. Allen. Princeton University Press, Princeton. vii + 253 pp., illus. Cloth U.S.\$45; paper U.S.\$14.50.

Insects and plant surfaces. 1986. Edited by Barrie Juniper and Richard Southwood. Koeltz Scientific, Koenigstein, West Germany. 368 pp. 118 DM.

Key environments: Red Sea. 1986. Edited by A. Edwards and S. Hea. Pergamon Press, Elmsford, New York. 300 pp., illus. U.S.\$29.20.

Land and its uses—actual and potential: an environmental appraisal. 1986. Edited by F. T. Last, M. C. B. Hotz, and B. G. Bell. From a seminar, Edinburgh, September 1982. Plenum, New York. xii + 597 pp., illus. U.S.\$85.

Marine pollution. 1986. By R. B. Clark. Clarendon (Oxford University Press), New York. xiv + 215 pp., illus. Cloth U.S.\$35; paper U.S.\$17.95.

Natural selection in the wild. 1986. By John A. Endler. Princeton University Press, Princeton. xiv + 337 pp., illus. Cloth U.S.\$40; paper U.S.\$13.95.

PCBs and the environment. 1986. Edited by John S. Waid. CRC Press, Boca Raton, Florida. 256 pp. U.S.\$92.

Physiological ecology of forest production. 1986. By J. J. Landsberg. Academic Press, New York. 216 pp. U.S.\$45.

Plankton dynamics of the South California Bight. 1986. Edited by R. W. Eppley. Springer-Verlag, New York. xiii + 373 pp. U.S.\$31.40.

†**Population ecology: a unified study of animals and plants.** 1986. By Michael Begon and Martin Mortimer. Second edition. Sinauer, Sunderland, Massachusetts. 220 pp., illus.

***Rivers and lakes in New Zealand.** 1986. By Kenneth Cumberland. Whitcoulls (U.S. distributor ISBS, Portland, Oregon). 128 pp., illus. U.S.\$29.95 plus U.S.\$2.25 postage.

Soil erosion and its control. 1986. Edited by R. P. C. Morgan. Van Nostrand Reinhold, New York. xvi + 311 pp., illus. U.S.\$42.50.

Tidal mixing and plankton dynamics. 1986. Edited by M. J. Bowman, C. M. Yentsch, and W. T. Peterson. Springer-Verlag, New York. x + 502 pp., illus. U.S.\$59.

Variability and management of large marine ecosystems. 1986. Edited by Kenneth Sherman and Lewis M. Alexander. From a symposium, New York, May 1984. Westview Press, Boulder, Colorado. xxvi + 319 pp., illus. U.S. \$31.85.

Miscellaneous

†**Audubon reader: the best writings of John James Audubon.** 1986. Edited by Scott Russell Sanders. Indiana University Press, Bloomington. viii + 254 pp. Cloth U.S. \$29.95; paper U.S. \$9.95.

Evolution: a theory in crisis. 1986. By Michael Denton. Adler and Adler, Washington. 368 pp., illus. U.S.\$19.95.

General photobiology. 1986. By D. P. Hader and V. M. Tevini. Pergamon Press, Elmsford, New York. 400 pp., illus.

Investigating the life sciences: an introduction to the philosophy of science. 1986. By G. M. N. Verschuuren. Pergamon Press, Elmsford, New York. 163 pp., illus. U.S.\$30.50.

McGraw-Hill encyclopedia of science and technology. 1987. Edited by McGraw-Hill. Sixth edition. McGraw-Hill, Toronto. 20 volumes, illus. \$1995.00.

Objectivity, science, and society: interpreting nature and society in the age of the crisis of science. 1986. By Paul A. Donesaroff. Methune, New York. x + 454 pp. U.S.\$55.

†**Uncovering Australia's dream time.** 1986. By Michael Archer, Suzanne Hand, and Henk Godthelp. Surrey Beatty, Chipping Norton, Australia. 33 pp., illus. A\$7.50.

Books for Young Naturalists

All wild creatures welcome: the story of a wildlife rehabilitation center. 1985. By Patricia Curtis. Lodestar (Dutton), New York. x + 130 pp., illus. U.S.\$13.95.

Killing the hidden waters: the slow destruction of water resources in the American southwest. 1985. By Charles Bowden. University of Texas Press, Austin. xii + 174 pp., illus. U.S.\$7.95.

Mouse. 1985. By Sara Bonnett Stein. Harcourt Brae Jovanovich, New York. 32 pp., illus. U.S.\$6.95.

Plants, seeds, and flowers. 1985. By Louis Sabin. Troll, Mahwah, New Jersey. 32 pp., illus. Cloth U.S.\$7.59; paper U.S.\$1.95.

Prehistoric animals. 1985. By Rae Bains. Troll, Mahwah, New Jersey. 32 pp., illus. Cloth U.S.\$7.59; paper U.S.\$1.95.

Reptiles and amphibians. 1985. By Louis Sabin. Troll, Mahwah, New Jersey. 32 pp., illus. Cloth U.S.\$7.59; paper U.S.\$1.95.

Rocks and minerals. 1985. By Rae Bains. Troll, Mahwah, New Jersey. 32 pp., illus. Cloth U.S.\$7.59; paper U.S.\$1.95.

The sacred paw: the bear in nature, myth, and literatures. 1985. By Paul Shepard and Barry Saunders. Viking, New York. xx + 244 pp., illus. U.S.\$17.95.

*assigned for review

†available for review

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The CANADIAN FIELD-NATURALIST

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Volume 101, Number 3

July-September 1987

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Cover: Single and fully doubled flowers of the White Trillium, *Trillium grandiflorum*, photographed near Ottawa. Courtesy of W. I. Illman, received 7 May 1986.

The Canadian Field-Naturalist

Volume 101, Number 3

July-September 1987

Recent Increases in the Breeding Population of Black-legged Kittiwakes, *Rissa tridactyla*, in Nova Scotia

A. R. LOCK

Canadian Wildlife Service, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2

Lock, A. R. 1987. Recent increases in the breeding population of Black-legged Kittiwakes, *Rissa tridactyla*, in Nova Scotia. Canadian Field-Naturalist 101(3): 331-334.

Black-legged Kittiwakes (*Rissa tridactyla*) began breeding in Nova Scotia around 1970. Since that time they have increased at a mean rate of 16% per annum to a 1983 population of 570 pairs. Their increase in Nova Scotia is related to a contemporaneous increase in the abundance of the sandlance (*Ammodytes* sp.).

Key Words: Black-legged Kittiwake, *Rissa tridactyla*, population, increase, *Ammodytes* sp., sandlance, Canada.

Black-legged Kittiwakes (*Rissa tridactyla*) are small, pelagic, cliff-nesting gulls with a circumboreal, subarctic and arctic breeding distribution. In Canada they bred traditionally on the arctic coasts, in the northern part of the Gulf of St. Lawrence, and in insular Newfoundland. The first known breeding south of this traditional range was on Green Island, off Cape Gabarus, Cape Breton Island (45°49', 60°04'W), where 99 nests were found in 1971 (Lock 1972). At that time no evidence of population expansion in North America had been advanced. In 1976 visiting birders noted a small colony of kittiwakes on the western side of Ciboux Island, off Cape Breton Island, the first indication that colonies were proliferating in Nova Scotia. In 1983 I found three new breeding sites, also on Cape Breton Island, and surveyed all the five known colonies there (Table 1 and Figure 1). The increase from 99 pairs in 1971 to 570 pairs in 1983 corresponds to a mean growth rate of almost 16% per annum.

Population history in eastern Canada

The high rate of Black-legged Kittiwake population growth observed in Nova Scotia is not atypical of other southern Canadian breeding groups. Also at the southern edge of their breeding range are kittiwakes breeding in sanctuaries on the north shore of the Gulf of St. Lawrence. These had shown no apparent growth prior to 1960, but since then their numbers have increased from 250 pairs to 3753 pairs in 1982, a mean annual increase of 13% (Chapdelaine and Brousseau (1984), and earlier censuses cited therein).

Before 1972 kittiwakes were not known to breed on the Labrador coast, but in that year I counted 16 nests on Outer Gannet Island (54°00'N, 56°32'W) in southern Labrador (Nettleship and Lock 1974). The colony had grown to approximately 55 nests in 1981 (D. Nettleship, personal communication) — a mean rate of annual increase of about 15%. Neither the more remote arctic-breeding kittiwake population nor the more accessible one in Newfoundland has been surveyed accurately or often enough to allow the status of these populations to be determined, but the arctic population is thought to be stable. Although the colonies in insular Newfoundland have not all been accurately surveyed, sufficient data exist to exemplify the increase there. Peters and Burleigh (1951) estimated that in 1949 24 000 pairs of kittiwakes bred in seven colonies at six sites on the island, though it is probable that more colonies existed then. According to Brown et al. (1975) about 65 000 pairs were known to breed at these same sites in 1973 and a total of 37 colonies were known.

Population history in Europe

Comparable increases have been noted elsewhere in the kittiwake's breeding range. In the first half of this century, kittiwake colonies in Europe were observed to grow and proliferate (review in Cramp et al. 1983), their breeding range extending south to Portugal and their choice of nesting habitat broadening to include building ledges and roofs. The number breeding in Great Britain has been periodically assessed with some accuracy and the mean annual growth rate in

TABLE 1—Black-legged Kittiwake (*Rissa tridactyla*) colonies in Nova Scotia in 1983. (Colony numbers refer to Figure 1).

Colony Number	Colony Name			Census Date	Total Nests
1	Ciboux Island	46°23'N	60°22'N	4 June 1983	232
2	Hertford Island	46°22'N	60°23'N	4 June 1983	13
3	Cape Perce	46°10'N	59°49'N	9 June 1983	87
4	Island off Baleine	45°56'N	59°49'N	9 June 1983	170
5	Green Island	45°49'N	60°04'N	10 June 1983	55
					567

this century has been 3-4% per annum (Coulson 1963). However, this rate of growth has not been maintained and in the decade 1969-1979 it was only 2% (Coulson 1983).

Brun (1979) reported increases in the breeding kittiwakes of northern Norway averaging only 1% per annum, although he noted a more rapid increase in the southern Norwegian colonies. Evans (1984) has documented, in a sample of six west Greenland kittiwake colonies, increases from 7605 pairs to 16 605 pairs between 1965 and 1974, a mean annual increase of 9%. In West Germany kittiwakes increased at a mean rate of 30% per annum from 1952 to 1962 and by 19.5% per annum from 1972 to 1982 (Evans 1984).

Possible causes of the increases

The differences in growth rates of Black-legged Kittiwake populations indicate great differences in their perceived environments. Before first breeding and outside the breeding season, kittiwakes are pelagic and disperse widely over the North Atlantic Ocean. There is no reason to expect that birds breeding in different regions are subject to very different mortality rates in these periods, though it is known that there is some assortment of wintering birds from different breeding places (Salomonson 1967). It seems likely that the significant differences occur in the breeding season. Coulson (1983) noted wide variations in rates of population change around the coast of Britain and argued that a single factor, operative in breeding season, was responsible: food availability. This is supported by Galbraith's (1983) observation that kittiwakes breeding on the Isle of May in the North Sea had difficulty in provisioning broods of three chicks.

Large increases in the abundance of sandlance (*Ammodytes* sp.) on Georges Bank and in the Gulf of Maine (Sherman et al. 1981) are contemporaneous

with the southward extension of the kittiwake's breeding range in North America. A similar *Ammodytes* increase has been reported on the Grand Bank (Winters 1983), and while there are no data on changes in *Ammodytes* abundances on the Scotian Shelf, it is reasonable to expect that comparable changes occurred there.

Breeding kittiwakes rarely, if ever, change their breeding colony, but immature birds and prospective breeders wander widely and move, in breeding season, from colony to colony (Coulson and White 1956, 1958; Coulson and Wooller 1976). It is likely that the colonies in Cape Breton were formed by immature birds from large Newfoundland colonies attracted to the area by an abundance of food and as adults, were able to return to the cliffs there to breed. The rapid growth of these colonies suggests that an abundance of food in the region is attractive to recruits, but this high growth rate is in part a function of colony size. Coulson (1983) showed that in Great Britain small colonies grow at a much faster rate than larger and older colonies.

The decrease in the growth rate of the British kittiwake population in the decade 1969-1979 was not general or uniform. Most colonies in the south and west decreased in size or remained stable, whereas the colonies in the north and east on the North Sea continued to grow at a rate comparable to that observed in previous decades. In the same period Stowe and Harris (1984) documented larger increases in the size of auk colonies on the North Sea coast of Britain than in colonies in the south and west.

This increase in the North Sea colonies was contemporaneous with an increase by 4× in the biomass of several species of small plankton-eating fish in the North Sea (Sherman et al. 1981). It is suggested that over-fishing of clupeid and scombrid stocks has resulted in their replacement by smaller,

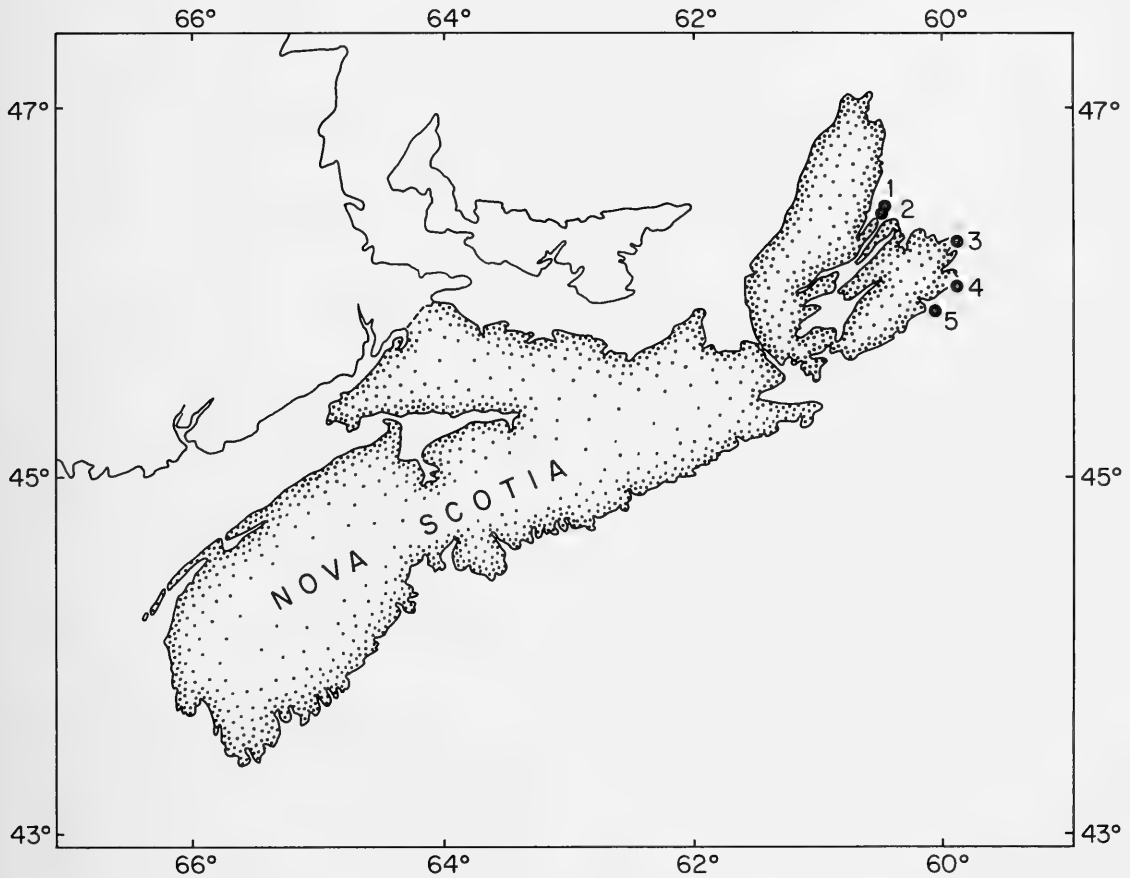


FIGURE 1. Black-legged Kittiwake (*Rissa tridactyla*) colonies in Nova Scotia.

faster growing, opportunistic species such as *Ammodytes* sp. on which kittiwakes and auks feed.

It is instructive to consider the changes in population of other species of seabirds breeding in Nova Scotia. Only Great Cormorants (*Phalacrocorax carbo*) and Double-crested Cormorants (*P. auritus*) have exhibited a similar population growth in the last decade (Milton and Austin-Smith 1983; Lock, unpublished data). The large gulls which feed chiefly in the intertidal zone and upon human wastes have not expanded, as rapidly as the small-fish eating seabirds. This supports the hypothesis that over-fishing of those species which are predators on the small fish on which both kittiwakes and cormorants feed has increased the food available to these birds and ultimately has been responsible for the observed population increases.

Acknowledgments

I acknowledge, gratefully, the field assistance of Ted Currie, Peter MacDonald and Michael Malone in surveying these colonies. The editorial attentions of A. J. Erskine and conversations with J. Porter much improved the paper.

Literature Cited

- Brown, R. G. B., D. N. Nettleship, P. Germain, C. E. Tull, and T. Davis. 1975. Atlas of eastern Canadian seabirds. Canadian Wildlife Service, Ottawa. 220 pp.
- Brun, E. 1979. Present status and trends in population of seabirds in Norway. Pages 289-301 in Conservation of marine birds of northern North America. Edited by J. C. Bartonek and D. N. Nettleship. United States Fish and Wildlife Service, Wildlife Research Report 11.

- Chapdelaine, G., and P. Brousseau.** 1984. Douzième inventaire des populations d'oiseaux marins dans les refuges de la Côte-Nord du golfe du Saint-Laurent. *Canadian Field-Naturalist* 98: 178-183.
- Coulson, J. C.** 1963. The status of the Kittiwake in the British Isles. *Bird Study* 10: 147-179.
- Coulson, J. C.** 1983. The changing status of the Kittiwake (*Rissa tridactyla*) in the British Isles, 1969-1979. *Bird Study* 30: 9-16.
- Coulson, J. C., and E. White.** 1956. A Study of colonies of the Kittiwake *Rissa tridactyla* (L.) *Ibis* 98: 63-79.
- Coulson, J. C., and E. White.** 1959. The post-fledging mortality of the Kittiwake. *Bird Study* 6: 97-102.
- Coulson, J. C., and R. D. Wooller.** 1976. Differential survival rates among breeding Kittiwake Gulls *Rissa tridactyla* (L.). *Journal of Animal Ecology* 45: 205-213.
- Cramp, S. Editor.** 1983. *Handbook of the Birds of Europe, the Middle East, and North America.* Oxford University Press. Volume 3.
- Evans, P. G. H.** 1984. The seabirds of Greenland: their status and conservation. Pp. 49-84 in *Status and conservation of the world's seabirds.* Edited by J. P. Croxall, P. G. H. Evans and R. Schreiber. I.C.B.P. Technical Publication No. 2.
- Galbraith, H.** 1983. The diet and feeding ecology of breeding Kittiwakes *Rissa tridactyla*. *Bird Study* 30: 109-120.
- Lock, A. R.** 1972. A Nova Scotian Kittiwake colony. *Canadian Field-Naturalist* 86: 291.
- Milton, G. R., and P. J. Austin-Smith.** 1983. Changes in the abundance and distribution of Double-crested (*Phalacrocorax auritus*) and Great (*P. carbo*) cormorants in Nova Scotia. *Colonial Waterbirds* 6: 130-138.
- Nettleship, D. N., and A. R. Lock.** 1974. Black-legged Kittiwakes breeding in Labrador. *Auk* 91: 173-174.
- Peters, H. S., and T. D. Burleigh.** 1951. *The birds of Newfoundland.* Department of Natural Resources, St. John's, Newfoundland. 431 pp.
- Salomonsen, F.** 1967. *Fuglene pa Gronland.* Translated by R. G. B. Brown. Rhodos, Copenhagen. 340 pp.
- Sherman, K., C. Jones, L. Sullivan, W. Smith, P. Berrien, and L. Ejsymont.** 1981. Congruent shifts in sand-eel abundance in western and eastern North Atlantic ecosystems. *Nature* 291: 486-489.
- Stowe, T. J., and M. P. Harris.** 1984. Status of Guillemots and Razorbills in Britain and Ireland. *Seabirds* 7: 5-18.
- Winters, G. H.** 1983. Analysis of the biological and demographic parameters of Northern Sandlance *Ammodytes dubius* from the Newfoundland Grand Banks. *Canadian Journal of Fisheries and Aquatic Sciences* 40: 409-419.

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A Study of Coastal Vegetation at a site on Hudson Bay near Winisk, Ontario

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Sims, R. A., G. M. Wickware, and D. W. Cowell. 1987. A study of coastal vegetation at a site on Hudson Bay near Winisk, Ontario. *Canadian Field-Naturalist* 101(3): 335-345.

Vegetation changes from the coast inland are described at a coastal Hudson Bay location 36 km northwest of Winisk, northern Ontario (55°44'N, 86°19'W). An 800-m survey line was run inland from the base of the most seaward beach ridge across the three youngest ridges and their two intervening swales. Occurrence and percent ground cover were recorded for all vascular and non-vascular species. Species richness and vegetational cover increased on each successive ridge inland, and a similar trend was noted in the swales. On the ridges, primary colonizers such as *Elymus mollis*, *Honkenya peploides* and *Hedysarum mackenzii* help to stabilize the substrate and ameliorate the effects of moisture stress and wind desiccation, allowing other species to become established. In both swales, broad gradients of salinity and peat accumulation appear to affect the establishment of taxa. The seaward end of the first swale supports only halophytic species, mainly *Puccinellia phryganodes* and *Carex subspathacea*, which colonize muddy sediments, while the upper portions of the second swale support fresh-water marsh species on a developing peat substrate.

Key Words: Hudson Bay Lowland, beach ridges and swales, coastal vegetation, subarctic ecology, primary succession, Ontario.

In the Hudson Bay Lowland a rapid rate of isostatic rebound is responsible for the development of extensive raised beach complexes along the Hudson and James bay shores. Conspicuous beach ridges and broad intervening swales parallel much of the 1130-km coastline in Ontario, and in places relict beach ridges may still be identified over 160 km inland (Coombs 1954). Vegetation shows a successive development as one moves from the coast inland the first few kilometres, from sparse plant cover on the youngest ridges through a series of beach ridges with a ground cover dominated by lichens or low herbaceous species, to a wooded condition on inland ridges (Moir 1954). For swales there is a similar succession from brackish meadow marshes through freshwater marshes, and then with accumulating peat soils and insulation from subjacent mineral soils, to open fens and peatland complexes (Wickware et al. 1981; Glooschenko 1980a).

In spite of their extensive nature and widely recognized importance as prime waterfowl and shorebird habitats, there is little published information on the shoreline ecosystems of the Hudson Bay area. Schofield (1959), Ritchie (1957) and Jefferies et al. (1979) have described coastal plant communities in the Churchill, Manitoba region. At East Pen Island near the Ontario-Manitoba border (Figure 1), vegetational zonations of salt marshes (Kershaw 1976), supratidal sedge meadows (Kershaw 1974) and

raised beach ridges (Kershaw and Rouse 1973; Larson and Kershaw 1974; Larson 1975) have been correlated with environmental variables. A phytosociological study of lichen-dominated raised-beach systems was conducted near Cape Henrietta-Maria, northwest James Bay (Figure 1; Neal and Kershaw 1973a, 1973b). At North Point, near Moosonee, southwestern James Bay, Glooschenko (1978) and Glooschenko and Harper (1982) studied aboveground plant biomass and primary productivity. Ringius (1980) and Pielou and Routledge (1976) have described vegetation zonation of brackish marshes at several coastal locations in southwestern James Bay. Sediment-vegetation interactions in James Bay tidal and supratidal ecosystems have been discussed generally (Glooschenko and Martini 1978).

Aside from floristic notes (Dutilly et al. 1959; Persson and Sjörs 1960; Riley 1979) and a general account (Glooschenko and Martini 1981), no published information is available on the vegetation of the Hudson Bay coastline between Cape Henrietta-Maria and Pen Island (Sims et al. 1979). The objectives of the study were: (1) to describe the flora from a representative coastal location approximately midway between Cape Henrietta-Maria and Pen Island, and (2) to show generally the successional changes as one proceeds across the youngest three beach ridges and their interrIDGE swales, from the coast inland.

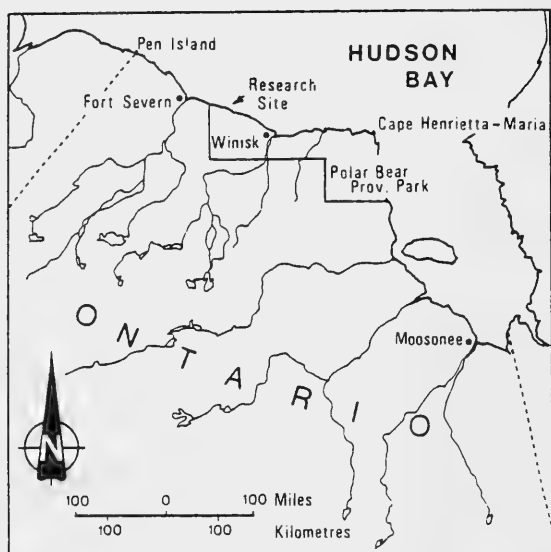


FIGURE 1. Map of the Hudson Bay Lowland, Ontario. Arrow indicates location of research site near Winisk, northern Ontario.

Research Site

The research site ($55^{\circ}44'N$, $86^{\circ}19'W$) is located 36 km northwest of Winisk, Ontario, on a representative beach ridge complex (Figures 1 and 2) within the perimeter of Polar Bear Provincial Park. Situated on a gently curving stretch of coastline, the ridges appear distinct from the air, although they are only a few metres in height above the general surface of the wet, broad swales between them.

At the research site, the ridges are composed mainly of gravels and coarse sands, sometimes with broader, apron-like sandy deposits on their leeward sides. Swale surface deposits are nutrient-rich marine silts and clays.

The Hudson Bay coast in Ontario experiences a cold maritime climate influenced by an ice pack in the bay that persists for much of the year (Danielson 1971). During the long winters, cold polar air masses move southward from the Arctic with little or no modification; short summers are characterized by frequent cool periods. The meteorological station at Winisk provides representative climatic data: an annual mean temperature of $-5.5^{\circ}C$ (mean daily for July, $11.0^{\circ}C$; for January, $-25.1^{\circ}C$) and an annual mean precipitation of 607.5 mm (Anonymous 1982a, 1982b). The southern Hudson Bay shore is considered one of the windiest areas in Canada, particularly in winter.

Methods

The research site was visited by helicopter in mid-July, 1978. A transect line was surveyed on a north-to-south bearing by means of a standard transit and rod. The line ran at an angle from the coast inland. It began at the seaward base of the first beach ridge, and crossed the first three ridges and their intervening swales (Figure 2). Along the 740m transect, a total of 221 1×1 m quadrats were randomly located. Sampling was stratified so that a roughly proportional number of quadrats fell into each swale and ridge segment according to the length of that segment. Vegetation measurements were taken from the coast inland and the first (most seaward) occurrence of each taxon was noted. Percent ground cover was estimated visually for all species in each quadrat. A complete plant collection was made, and vouchers have been deposited at the Great Lakes Forestry Centre (SSMF) herbarium; nomenclature follows Porsild and Cody (1980) for the vascular plants, Ireland and Cain (1975) for the mosses, Stotler and Crandall-Stotler (1977) for

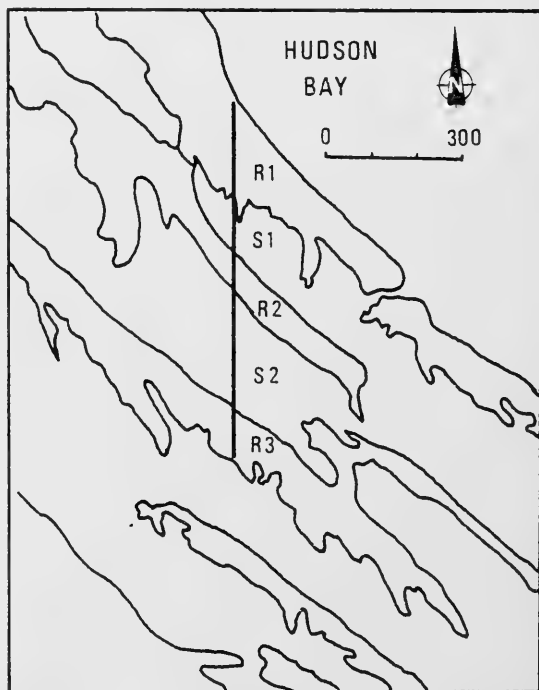


FIGURE 2. Vertical view of the transect line across the first three beach ridges. Map derived from an enlargement of National Air Photo Library photo number A24484-142 (1:60 000 black and white panchromatic).

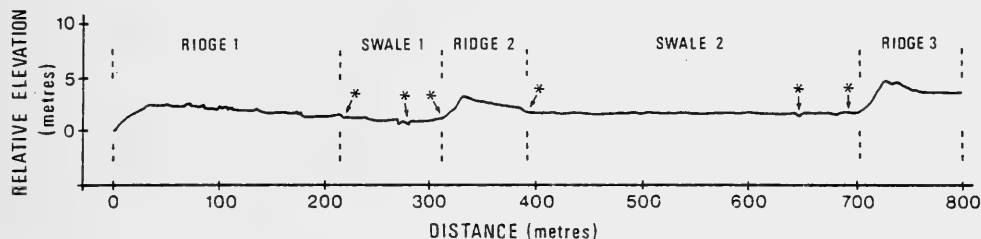


FIGURE 3. Profile of the surveyed line showing ground distances and exaggerated ($\times 10$) elevations. Stations where environmental measures (Table 2) were made are indicated with symbols (*).

the hepatics, and Hale and Culberson (1970) for the lichens.

In each of the two swales, three stations were established, one at the north edge, one in the centre and one at the south edge, and the following were measured in the field: depth to water level, specific conductance and salinity of the groundwater, and depth of organic soil. The ground was probed to a depth of 1 m in the swales but no permafrost was encountered.

Results

The Ridges

The three ridges accounted for 49% (389 m) of the transect's length, with the first ridge being the widest at 214 m (Figure 3). In relation to the initial benchmark on the seaward side of the first ridge, maximum elevations were 2.8 m on the first ridge, 3.4 m on the second and 4.8 m on the third. Although the ridges are still under the influence of wind-deflation and perhaps some erosion by high storm waters, approximate ages can be inferred from their relative heights by applying the estimate of Webber et al. (1970) for isostatic uplift rates at Cape Henrietta-Maria. The first ridge is the youngest (30 to 70 years old), while the second and third ridges are about 100 and 150 years old, respectively.

Some 136 plant species were encountered along the transect, including 93 vascular and 43 non-vascular species (Table 1). Species richness, i.e., the number of species, increased from the coast inland. Forty-one plant species occurred on the first ridge but this number increased to 50 on the second, and 57 on the third. The first swale had 18, while the second had 74. Floristically the dry ridge communities were distinct from the swale communities, with only 23% (31 of 136) of the taxa common to both (Table 1); furthermore, most of these occupied only those habitats which were adjacent to ridge and swale borders. All of the beach ridge-swale borders were abrupt and easily demarcated in the field.

The foreslope and crest of the first ridge were unvegetated. The most seaward plants encountered were depauperate clumps of *Elymus mollis* (Sea Lyme Grass) growing among driftwood strands just inland of the crest. Plants of this species typically grow in clonal mats, root deeply, tiller freely and produce numerous horizontal rhizomes. The long backslope of the first ridge, however, was well colonized by a variety of soil-stabilizing species adapted to the dry, gravelly and windblown environment. Most frequent was *Honkenya peploides* (Seabeach Sandwort), which occurred in about one quarter of the 63 quadrats established on the ridge, and attained a ground cover of 2 to 4% (Table 1). Other species in the 2 to 4% cover class were *Artemisia borealis*, *Elymus mollis*, *Festuca rubra* (Red Fescue) and *Hedysarum mackenzii*. Notably absent were lichens (except for *Xanthoria elegans* which occurred infrequently on small stones), probably because of the young age of the ridge. Total vegetation cover on the ridge was only 12% (Figure 4).

The vegetation on the second ridge was similar to that on the first except for generally greater percent cover and frequency values. The surface of the ridge was irregular because of the formation of numerous small deflation hollows and miniature dunes. This phenomenon aids primary succession by creating microsites favorable to species less tolerant of exposure. The most frequently occurring (42%) and abundant (10 to 19% cover class) plant was the legume *Hedysarum mackenzii*, which contributes to soil buildup of nitrogen compounds. It typically establishes itself in large, usually circular, tap-rooted patches. Along with *Saxifraga tricuspidata* (Prickly Saxifrage), *Elymus mollis* and *Honkenya peploides*, *Hedysarum mackenzii* formed a generally discontinuous cover on the second ridge, particularly on the crest and backslope. *Tortula ruralis* was the only non-vascular plant that attained any significant cover (5 to 9% class) on the second ridge. It is a pronounced calcophile that is a common and effective sand dune

TABLE 1. Plant taxa encountered in a survey of coastal beach ridge (R1, R2, R3) and swale (S1, S2) vegetation, southern Hudson Bay. Taxa are listed according to their first occurrence along a transect from the coast inland. Mean percent cover class ($1 \leq 1\%$, $2 = 2-4\%$, $3 = 5-9\%$, $4 = 10-19\%$, $5 \geq 20\%$) and in parentheses, frequency, are summarized for the three ridges and two swales.

Structural category ^a	Species	R1 coast (n = 63)	S1 (n = 47)	R2 (n = 38)	S2 (n = 44)	R3 inland (n = 29)
3	<i>Elymus mollis</i>	2 (14)		2 (26)	1 (2)	3 (72)
2	<i>Mertensia maritima</i>	1 (2)		1 (5)		
2	<i>Honckenya peploides</i>	2 (25)		2 (29)		
2	<i>Artemisia borealis</i>	2 (14)		1 (24)		
5	<i>Xanthoria elegans</i>	1 (2)		1 (24)		1 (24)
2	<i>Rhinanthus borealis</i>	1 (3)		1 (11)		1 (10)
2	<i>Hedysarum mackenzii</i>	2 (13)		4 (42)		3 (62)
2	<i>Stellaria longipes</i>	1 (8)		2 (29)		1 (21)
2	<i>Gentianella propinqua</i> ssp. <i>propinqua</i>	1 (8)		1 (3)		
2	<i>Euphrasia hudsoniana</i>	1 (14)		1 (5)		
2	<i>Solidago multiradiata</i>	1 (6)		1 (11)	1 (7)	3 (69)
2	<i>Androsace septentrionalis</i>	1 (6)		1 (11)		
3	<i>Poa alpina</i>	1 (5)		1 (5)	1 (2)	2 (41)
2	<i>Achillea millefolium</i>	1 (3)		2 (13)	1 (5)	2 (48)
2	<i>Linum lewisii</i> ssp. <i>lepagei</i>	1 (5)		1 (5)	1 (2)	
1	<i>Salix arctophila</i>	1 (6)		1 (3)	2 (18)	1 (21)
2	<i>Castilleja raupii</i>	1 (11)		1 (13)	1 (9)	
3	<i>Trisetum molle</i>	1 (5)		1 (18)		
4	<i>Tortula ruralis</i>	1 (10)		2 (37)		
2	<i>Astragalus alpinus</i>	1 (8)		2 (29)	1 (5)	2 (34)
2	<i>Arabis arenicola</i> var. <i>pubescens</i>	1 (5)		1 (11)		
2	<i>Saxifraga tricuspidata</i>	1 (16)		3 (24)	1 (2)	4 (86)
3	<i>Festuca rubra</i>	2 (10)	3 (34)	1 (11)		1 (31)
2	<i>Draba aurea</i>	1 (8)		1 (13)		1 (21)
2	<i>Lomatogonium rotatum</i>	1 (11)		1 (5)	1 (7)	
4	<i>Bryum</i> sp.	1 (5)		1 (3)		
3	<i>Poa pratensis</i> var. <i>alpigena</i>	1 (8)		1 (5)		
2	<i>Erigeron lonchophyllus</i>	1 (5)		1 (8)		1 (14)
2	<i>Gentianella detonsa</i>	1 (11)				
2	<i>Anemone multifida</i>	1 (6)		1 (8)		1 (14)
2	<i>Draba incana</i> var. <i>confusa</i>	1 (3)			1 (2)	1 (7)
4	<i>Bryum algovicum</i>	1 (2)		1 (3)	1 (5)	
1	<i>Shepherdia canadensis</i>	1 (2)			1 (7)	1 (10)
3	<i>Calamagrostis stricta</i>	1 (2)			4 (61)	
4	<i>Distichium capillaceum</i>	1 (11)	1 (4)		1 (9)	1 (7)
2	<i>Sagina nodosa</i>	1 (5)				
3	<i>Carex bicolor</i>	1 (3)				
2	<i>Parnassia palustris</i> ssp. <i>neogaea</i>	1 (8)				
3	<i>Juncus balticus</i> var. <i>littoralis</i>	1 (3)		1 (5)	1 (7)	1 (7)
4	<i>Meesia uliginosa</i>	1 (3)	1 (6)		2 (25)	
2	<i>Potentilla egedii</i> ssp. <i>egedii</i>	1 (6)	2 (26)			
4	<i>Leptobryum pyriforme</i>		3 (64)			
3	<i>Puccinellia phryganodes</i>		5 (94)			
3	<i>Carex glareosa</i>		3 (30)		4 (45)	
2	<i>Primula stricta</i>		1 (6)		1 (5)	
3	<i>Carex subspathacea</i>		5 (49)	1 (5)	3 (39)	
2	<i>Plantago maritima</i>		2 (15)	1 (3)		
2	<i>Triglochin palustris</i>		1 (4)		1 (11)	
4	<i>Desmatodon heimii</i> var. <i>arctica</i>		2 (26)			
2	<i>Stellaria humifusa</i>		1 (15)			
4	<i>Meesia triquetra</i>		2 (21)		3 (27)	

(continued)

TABLE 1. (Continued)

Structural category ^a	Species	R1 coast (n = 63)	S1 (n = 47)	R2 (n = 38)	S2 (n = 44)	R3 inland (n = 29)
2	<i>Potentilla egedii</i> ssp. <i>grandis</i>		1 (13)	1 (8)	1 (11)	
2	<i>Ranunculus cymbalaria</i>		1 (4)		1 (5)	
2	<i>Hippuris vulgaris</i> f. <i>maritima</i>		3 (13)		1 (7)	
2	<i>Potamogeton filiformis</i>		1 (2)			
1	<i>Salix glauca</i> var. <i>callicarpaea</i>			1 (11)	2 (18)	2 (24)
4	<i>Ceratodon purpureus</i>			1 (16)		
1	<i>Salix reticulata</i>			1 (8)	1 (11)	
2	<i>Draba glabella</i>			1 (8)	1 (5)	
4	<i>Aulacomnium palustre</i>			1 (18)	2 (27)	1 (31)
1	<i>Salix brachycarpa</i> ssp. <i>brachycarpa</i>			1 (5)	2 (25)	1 (17)
4	<i>Desmatodon cernuus</i>			1 (3)		
1	<i>Dryas integrifolia</i>			1 (11)	1 (3)	1 (14)
2	<i>Pinguicula vulgaris</i>			1 (5)	1 (5)	
2	<i>Oxytropis viscida</i> var. <i>hudsonica</i>			1 (13)		1 (14)
2	<i>Tofieldia pusilla</i>			1 (8)	1 (7)	
3	<i>Luzula multiflora</i> var. <i>frigida</i>			1 (8)		1 (7)
1	<i>Empetrum nigrum</i> ssp. <i>hermaphroditum</i>			1 (8)		1 (3)
5	<i>Rhizocarpon geographicum</i>			1 (16)		1 (21)
3	<i>Festuca brachyphylla</i>			1 (3)		1 (10)
5	<i>Parmelia sulcata</i>			1 (5)		
1	<i>Salix lanata</i> ssp. <i>calcicola</i>				1 (5)	
1	<i>Betula pumila</i> var. <i>glandulifera</i>				1 (23)	
3	<i>Carex capillaris</i>				1 (11)	
4	<i>Brachythecium salebrosum</i>				1 (5)	
2	<i>Rumex fenestratus</i>				1 (7)	
2	<i>Petasites sagittatus</i>				1 (11)	
2	<i>Cardamine pratensis</i> ssp. <i>angustifolia</i>				1 (5)	
2	<i>Epilobium palustre</i>				1 (16)	
4	<i>Paludella squarrosa</i>				2 (16)	
1	<i>Arctostaphylos rubra</i>				1 (5)	
2	<i>Platanthera obtusata</i>				2 (11)	
3	<i>Carex aquatilis</i>				1 (20)	
3	<i>Poa glauca</i>				1 (3)	
4	<i>Drepanocladus uncinatus</i>				4 (55)	
3	<i>Carex diandra</i>				2 (18)	
3	<i>Juncus arcticus</i>				1 (5)	
4	<i>Plagiomnium ellipticum</i>				2 (18)	
2	<i>Equisetum scirpoides</i>				1 (23)	
1	<i>Salix candida</i>				2 (11)	
4	<i>Scorpidium turgescens</i>				2 (27)	
2	<i>Triglochin maritima</i>				2 (7)	
1	<i>Salix pedicellaris</i>				1 (11)	
3	<i>Dupontia fisheri</i> var. <i>psilosantha</i>				2 (18)	
3	<i>Carex microglochin</i>				1 (3)	
2	<i>Eleocharis smallii</i>				1 (5)	
3	<i>Juncus triglumis</i> var. <i>albescens</i>				1 (3)	
3	<i>Carex rariflora</i>				1 (11)	
4	<i>Calliergon giganteum</i>				2 (16)	
4	<i>Helodium blandowii</i>				1 (3)	
3	<i>Calamagrostis deschampsoides</i>				1 (5)	
4	<i>Tomenthypnum nitens</i>				1 (11)	
2	<i>Potentilla palustris</i>				1 (23)	
3	<i>Trichophorum hudsonianus</i>				1 (3)	

(continued)

TABLE 1. (Concluded)

Structural category ^a	Species	R1 coast (n = 63)	S1 (n = 47)	R2 (n = 38)	S2 (n = 44)	R3 inland (n = 29)
4	<i>Cratoneuron filicinum</i>				1 (5)	
2	<i>Senecio congestus</i>				1 (16)	
2	<i>Myriophyllum exalbescent</i>				1 (3)	
4	<i>Ditrichum flexicaule</i>				1 (11)	2 (31)
1	<i>Salix planifolia</i> ssp. <i>planifolia</i>				1 (5)	1 (7)
4	<i>Aulacomnium turgidum</i>				1 (5)	2 (17)
2	<i>Botrychium lunaria</i>				1 (3)	1 (3)
4	<i>Leptodictyum trichopodium</i> var. <i>kochii</i>				1 (3)	1 (10)
4	<i>Hylocomium splendens</i>					2 (17)
2	<i>Taraxacum ceratophorum</i>					2 (7)
2	<i>Potentilla multifida</i>					1 (3)
2	<i>Epilobium angustifolium</i>					1 (7)
2	<i>Cerastium alpinum</i>					1 (10)
2	<i>Ranunculus pedatifidus</i> ssp. <i>affinis</i>					1 (7)
3	<i>Poa arctica</i>					1 (7)
4	<i>Polytrichum strictum</i>					1 (14)
5	<i>Alectoria ochroleuca</i>					1 (21)
4	<i>Abietinella abietina</i>					2 (41)
5	<i>Cetraria cucullata</i>					3 (72)
4	<i>Rhytidium rugosum</i>					2 (31)
5	<i>Ochrolechia geminipara</i>					2 (14)
5	<i>Cladina rangiferina</i>					2 (10)
5	<i>C. stellaris</i>					2 (10)
5	<i>Umbilicaria hyperborea</i>					2 (14)
5	<i>Cetraria islandica</i>					1 (3)
5	<i>Cladonia coccifera</i>					1 (3)
5	<i>C. cornuta</i>					1 (7)
5	<i>Stereocaulon alpinum</i>					1 (7)
5	<i>Cladonia fimbriata</i>					1 (3)
5	<i>Peltigera rufescens</i>					1 (3)
2	<i>Potentilla nivea</i>					1 (3)
5	<i>Stereocaulon tomentosum</i>					2 (17)

^aStructural category: 1 = woody-shrubs; 2 = broad-leaved herbs; 3 = graminoids (i.e., grass and grass-like plants of the families *Gramineae*, *Cyperaceae*, and *Juncaceae*); 4 = bryophytes; 5 = lichens.

stabilizer in arctic and boreal areas (Crum 1983). A few shrubby *Salix* (willow) spp. occurred on the ridge mainly along its protected southern edge, but they attained little in the way of height. Most were under 50 cm tall. The total vegetation cover of 53% consisted primarily of vascular species (Figure 4).

The third ridge was the furthest removed from the direct effects of wind and water erosion. Although this ridge was still relatively young at 100 to 150 years, some soil development had occurred and for the most part the ridge surface had been stabilized by primary colonizers. As a consequence, percent ground cover by all vegetation was much higher at 94%, of which a significant portion was non-vascular cover (figure 4). Twenty-four species in this survey were unique to the third ridge and half were lichen species (Table 1). *Saxifraga tricuspidata* was the most frequent (86%)

and abundant (10 to 19% class) plant, although four others were in the 5 to 9% cover range: *Solidago multiradiata*, *Elymus*, *Hedysarum* and the lichen *Cetraria cucullata*. The most common moss was *Abietinella abietina* (41% frequency, 2 to 4% cover class), a robust, calciphilous feathermoss with distinct arctic affinities. There was a more pronounced differentiation of vegetation communities across the third ridge than across the other ridges. The north-facing slope was more sparsely vegetated, covered primarily by a *Saxifraga-Hedysarum-Elymus* association. The crest was also covered by these species, but they were in association with a moss and lichen flora together with a variety of vascular species such as *Cerastium alpinum*, *Dryas integrifolia*, *Astragalus alpinus*, and *Draba* spp. The backslope had a sparse shrub stratum up to 1.5 m of *Salix*

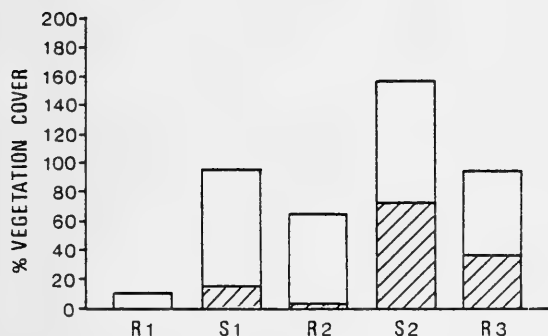


FIGURE 4. Histogram showing the total percentage ground cover by vascular and non-vascular (hatched areas) vegetation on the ridges (R1, R2, R3) and in the swales (S1, S2).

glauca, *S. brachycarpa* and *S. planifolia* with herbaceous and ground layer vegetation similar to that covering the ridge crest.

The Swales

Although the general landbase slopes gently seaward at a rate of approximately 60 cm/km in this part of the Hudson Bay Lowland (Webber et al. 1970), the survey line indicated that both swales are slightly elevated toward their seaward ends (Figure 3). The seaward end of the first swale had an elevation of 1.4 m (in relation to the seaward base of the first ridge) while the inland end of this swale was 1.2 m above the same benchmark. Similarly, the elevation of the second swale was 2.0 m at the seaward end and 1.8 m at the inland end. This may be due to backwash and settling of sediments during early development of the swale systems, along with contribution of some loess materials from the windblown, unvegetated ridges to the seaward ends of the swales. Elevational differences within the swales were slight (Figure 3).

The swale between the first and second ridge has been at least seasonally inundated by flowing water, probably during periods of spring runoff, and possibly during major storm surges. Hudson Bay beach ridges trap and redirect drainage flows so that slot-shaped pools or shallow lakes frequently develop among them. Such was the case with the first swale; a large shallow pool (up to 50 cm deep) existed through the central portion of it, and provided a habitat for a number of aquatic or semi-aquatic plant species, e.g., *Potamogeton filiformis*, *Juncus balticus*, *Ranunculus cymbalaria* (Seaside Crowfoot) and *Hippuris vulgaris* (Mare's-tail). The graminoids *Puccinellia phryganeodes* (94%) and *Carex subspathacea* (49%) were the most frequent vascular species in the first swale (Table

1). Both are favored for grazing by waterfowl, especially Snow Geese (*Anser caerulescens*), and both are commonly found in extensive meadow marshes along the southern Hudson Bay shore in Ontario and Manitoba (Glooschenko 1980a; Glooschenko and Martini 1981; Jefferies et al. 1979; Kershaw 1976). *Leptobryum pyriforme*, a small carpet-forming moss, was the most common non-vascular species in the first swale (34% occurrence, 5 to 9% cover class). Gill (1971) noted that this species is a prolific primary colonizer on new alluvial sites in the Mackenzie River Delta.

A number of halophytes occurred in the first and second swale, including *Hippuris vulgaris* f. *maritima*, *Senecio congestus* (Marsh-fleabane), *Triglochin palustris*, *Carex subspathacea* and *Plantago maritima* (Seaside-plantain). Salinity at stations in the swales was as high as 15 o/oo (Table 2). With drier conditions later in the summer one would expect these readings to range even higher. Water levels in both swales were at or very near the surface. Within each swale, salinity decreased as one moved inland from more saline habitats seaward to less saline habitats inland (Table 2). In the second swale no salinity was detected at the last station. In fact, the water conductivity reading of 450 μ mhos was more in line with that expected for a freshwater marsh or a rich open fen (cf. Sims et al. 1982). Organic soils began to develop at the rear of the first swale but significant accumulations (i.e. 20 cm) were not encountered until the rear of the second where a 38-cm depth was found (Table 2). With this trend, one would expect to find true peat soils with over 40 cm of organic matter in the next swale inland from the third beach ridge.

The second swale was broad, constituting about 39% (314 m) of the length of the transect, and provided a variety of habitats along a gradient of increasing peat depth and decreasing salinity (Table 2). Seventy-four taxa were recorded for this area, and

TABLE 2. Environmental measures in the swales (S1, S2).

Station	Depth to water level (cm)	Specific conductance (μ mhos at 25°C)	Salinity (o/oo)	Depth of peat (cm)
S1				
— lower	13	17 000	15.0	0
— middle	0	5 000	4.0	0
— upper	0	740	0.6	5
S2				
— lower	2	2 400	2.0	13
— middle	0	1 900	1.8	3
— upper	5	450	—	38

36 were unique to it. The most frequent species were: *Calamagrostis stricta* (61%), *Drepanocladus uncinatus* (55%), *Carex glareosa* (45%), *C. subspathacea* (39%), *Meesia triquetra* (27%) and *Aulacomnium palustre* (27%). Three species in this list are mosses; a greater proportion of the total vegetation cover was provided by non-vascular species, especially mat-forming mosses, in the second swale (Figure 4). Vegetation associations on the swale were intergraded. At the seaward edge, where salinities were higher, the vegetation was similar to that of the first swale with *Puccinellia phryganodes*, *Carex subspathacea*, and other species growing in a lawn-like meadow marsh. In the center of the swale, broad *Carex glareosa*-*Drepanocladus* and *Calamagrostis stricta*-*Drepanocladus* marshes were dissected by occasional small pools supporting patchy growth of *Senecio congestus*, *Hippuris vulgaris* or *Salix* spp. along the margins. The inland end of the swale supported a patchy cover of low-growing *Salix brachycarpa*, *S. glauca*, *Betula pumila* (Swamp-birch) and *Juncus balticus*, in association with the mosses

Calliergon giganteum, *Drepanocladus uncinatus* and *Paludella squarrosa*.

Discussion

The Ridges

Hardy species are dominant on the ridges, probably because of the continuous exposure to wind stress and scouring, and moisture stress. On the first ridge, where these conditions were most extreme and the substrate was unstabilized, only clonal growing plants of *Honkenya peploides* (Figure 5), *Elymus mollis*, *Hedysarum mackenzii* and *Saxifraga tricuspidata* were well established. On the second ridge, with high percentage cover by vegetation (Figure 4) and hence some soil stabilization, more vascular species had colonized. On the third ridge, the temporal sequence had proceeded sufficiently for the establishment of a significant lichen and moss ground cover, and the development, on the backslope, of woody ericaceous and *Salix* species in a shrub (up to 1.5 m) overstory. The herbaceous layer was more diverse and the blowout areas and knolls of the ridge provided a



FIGURE 5. *Honkenya peploides* establishing along the backslope of the first beach ridge. Note how the matted growth form tends to collect sand particles moving along the beach surface so that colonies may be raised several cm above the general surface.

number of microsites for plants unable to grow on the exposed seaward ridges. Increased vegetational cover as one moves inland is particularly important to the development of soil moisture capacity through the buildup of soil organic matter, and the stabilization of substrates. As moisture conditions become more favorable, additional species can then become established (Rouse and Kershaw 1973).

The ridges examined in the present study were younger and less vegetated than the 250- to 800-year-old lichen-clad ridges examined by Larson and Kershaw (1974) at Pen Island. At a site near Pen Island, Rouse and Kershaw (1973) describe the first beach ridge inland as having a vegetation cover of 49% consisting mainly of *Dryas integrifolia* growing in patches 1 m in diameter and interspersed with patches of sandy and gravelly soil about 2 m in diameter.

The ridges described here are also floristically quite different from any of the 11 lichen-dominated vegetation associations described for Cape Henrietta-Maria beach ridges (Neal and Kershaw 1973a, 1973b). The "central lichen heath association" which accounted for a large proportion of the vegetational cover at Cape Henrietta-Maria (Neal and Kershaw 1973a) and which was also found extensively at East Pen Island (Kershaw and Rouse 1973) was not encountered, although some of the characteristic floristic elements (e.g. *Hedysarum mackenzii*, *Dryas integrifolia*, *Cladina rangiferina*) were present with restricted cover on the second and third ridges. It may be that in addition to supporting younger substrates, the ridges near Winisk are subjected to a less severe climate than the more northerly Pen Island area or the very exposed cape area. The ridge flora differs, however, from that found on more southerly beach ridges in the Hudson Bay Lowland. On southwestern James Bay coastal ridges, for example, typical primary colonizers include *Lathyrus maritimus*, *Artemisia tilesii*, *Gentianella amarella* (Felwort), *Fragaria virginiana* and *Hordeum jubatum* (Squirrel-tail Grass) in addition to *Elymus mollis*, *Honkenya peploides*, *Rhinanthus borealis* and *Stellaria longipes* (Riley and MacKay 1980).

Percentage cover of vegetation appears to be strongly related to aspect (Table 3). The unvegetated,

exposed slope of the first ridge and the sparsely vegetated north side of the second ridge contrasted in particular with the more heavily vegetated leeward slopes. Microclimate characteristics, particularly wind speed, air temperature and soil moisture, have been shown to have controlling influences on vegetation distribution on beach ridges at Pen Island (Larson 1975).

The Swales

Both swales support intergrading vegetational communities that defy simple zonation, an observation that Kershaw (1976) made previously while studying a broad salt marsh area at Pen Island. There was a continuous sequence of species distribution from seaward to inland, with the seaward portion supporting more halophytic species and the inland, particularly in the second swale, supporting freshwater fen and marsh species. Unlike the marsh studied by Kershaw (1976), no permafrost was encountered within 1 m of the swale surface. Melting seasonal ice earlier in the year, however, may contribute to dilution of salt water, and perpetuation of the saline to freshwater gradient within the swales (Table 2). Differences in elevation and the accumulation of peat material must also influence species distribution in the swales.

Puccinellia phryganodes, the dominant graminoid in the first swale, is widely distributed in Canadian arctic salt marshes, propagating by long stolons, and forming extensive mats in mud flats (Jefferies 1977). The other dominant species in the first swale, *Carex subspathacea*, usually seems to establish itself on slightly higher mud flats, mostly inland from the extensive *Puccinellia* mats, but their habitats intergrade. Nordhagen (1954) similarly observed no sharp border between these two on salt marshes in Norway, although *Carex subspathacea* always developed inland of *Puccinellia*. In their coastal habitats along southwestern Hudson Bay these two taxa are sometimes partially covered by detritus and algae deposited during surge tides, but typically attain a lustrous dark green and appear to grow vigorously.

The freshwater associations that develop in the inland half of the second swale are comparable to associations described from similar environments. Along southwestern James Bay supratidal meadow marshes develop, which are frequently dominated by the graminoid *Calamagrostis stricta* in association with *Juncus balticus*, *Deschampsia caespitosa* (Tufted Hairgrass) or *Carex paleacea* (Riley and Mackay 1980; Ringuis 1980). At Pen Island, freshwater marshes just inland from tidal influences are dominated by *Calamagrostis stricta* in association with a variety of other species, most notably *Carex*

TABLE 3. Comparison of total percent cover by vegetation on north (N) and south (S) aspects of R1, R2, and R3. Within parentheses, percent cover by non-vascular taxa only.

	N	S
R1	0 (0)	22 (tr)
R2	23 (1)	79 (4)
R3	76 (25)	116 (34)

aquaticilis, *Cardamine pratensis* (Cuckoo-flower), some small *Salix* spp. and the mosses *Drepanocladus exannulatus* and *Scorpidium scorpioides* (Kershaw 1976). Associations of *Carex glareosa* and *Festuca rubra* with extensive mats of *Drepanocladus uncinatus* develop above salt marshes in Norwegian fjords (Nordhagen 1954).

All of the taxa occurring in the swales have previously been recorded by other authors in similar Hudson Bay Lowland habitats (Schofield 1959; Kershaw 1974, 1976; Larson 1975; Ringius 1980; Riley and MacKay 1980; Glooschenko 1980b; Glooschenko and Martini 1981; Glooschenko and Harper 1982). Kershaw (1976) has remarked on the similarity between the salt marsh vegetation at Pen Island and that of other arctic marshes in Canada and Scandinavia. Schofield (1959) and Jefferies et al. (1979) have made similar comments regarding coastal marshes near Churchill, Manitoba. The present study confirms Kershaw's (1976) suggestion that the salt marsh to fresh marsh sequence he described at Pen Island is similar at other locations along the southern Hudson Bay coast in Ontario.

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Literature Cited

- Anonymous.** 1982a. Canadian climate normals, Volume 2. Temperature, 1951–1980. Department of the Environment, Atmospheric Environment Service, Ottawa. 306 pp.
- Anonymous.** 1982b. Canadian climate normals, Volume 3. Precipitation, 1951–1980. Department of the Environment, Atmospheric Environment Service, Ottawa. 602 pp.
- Coombs, D. B.** 1954. The physiographic subdivisions of the Hudson Bay Lowlands south of 60 degrees north. Geographical Bulletin 6: 1–16.
- Crum, H.** 1983. Mosses of the Great Lakes forest. Third edition. University of Michigan Press, Ann Arbor, Michigan. 417 pp.
- Danielson, E. W.** 1971. Hudson Bay ice conditions. Arctic 24: 90–107.
- Dutilly, A. A., Lepage, E., and M. Duman.** 1959. A collection of plants from Winisk, Ontario. Le Naturaliste canadien 85: 214–218.
- Gill, D. E.** 1971. Vegetation and environment in the Mackenzie River Delta: a study in subarctic ecology. Ph.D. thesis, University of British Columbia, Vancouver, British Columbia. 694 pp.
- Glooschenko, W. A.** 1978. Above-ground biomass of vascular plants in a subarctic James Bay salt marsh. Canadian Field-Naturalist 92: 30–37.
- Glooschenko, W. A.** 1980a. Coastal ecosystems of the James/Hudson Bay area of Ontario, Canada. Pp. 214–224 in Zeitschrift für geomorphologie, Supplement 34.
- Glooschenko, W. A.** 1980b. Coastal salt marshes in Canada. Pp. 39–47 in Proceedings of a workshop on Canadian wetlands. Department of the Environment, Lands Directorate, Ottawa, Ontario, Ecological Land Classification Series, Number 12.
- Glooschenko, W. A., and N. S. Harper.** 1982. Net aerial primary production of a James Bay, Ontario, salt marsh. Canadian Journal of Botany 60: 1060–1067.
- Glooschenko, W. A., and I. P. Martini.** 1978. Hudson Bay Lowland baseline study. Pp. 663–679 in Proceedings of the Coastal Zone '78: ASCE, San Francisco, California.
- Glooschenko, W. A., and I. P. Martini.** 1981. Salt marshes of the Ontario coast of Hudson Bay, Canada. Wetlands 1: 9–18.
- Hale, M. E. Jr., and W. L. Culberson.** 1970. A fourth checklist of the lichens of the continental United States and Canada. Bryologist 73: 499–543.
- Ireland, R. R., and R. F. Cain.** 1975. Checklist of the mosses of Ontario. National Museum of Natural Sciences, Ottawa, Publications in Botany Number 5. 67 pp.
- Jefferies, R. L.** 1977. The vegetation of salt marshes at some coastal sites in arctic North America. Journal of Ecology 65: 661–672.
- Jefferies, R. L., A. Jensen, and K. F. Abraham.** 1979. Vegetational development and the effect of geese on vegetation at La Perouse Bay, Manitoba. Canadian Journal of Botany 57: 1439–1450.
- Kershaw, K. A.** 1974. Studies on lichen dominated systems. X. The sedge meadows of the coastal raised beaches. Canadian Journal of Botany 52(8): 1947–1972.
- Kershaw, K. A.** 1976. The vegetational zonation of the East Pen Island salt marshes, Hudson Bay. Canadian Journal of Botany 54: 5–13.
- Kershaw, K. A., and W. R. Rouse.** 1973. Studies on lichen-dominated systems. V. A primary survey of a raised-beach system in north-western Ontario. Canadian Journal of Botany 51: 1285–1307.
- Larson, D. W.** 1975. Aspects of the ecology of coastal tundra raised-beach ridges in northwestern Ontario. Ph.D. thesis, McMaster University, Hamilton, Ontario. 163 pp.
- Larson, D. W., and K. A. Kershaw.** 1974. Studies on lichen-dominated systems. VII. Interaction of the general lichen-heath with edaphic factors. Canadian Journal of Botany 52: 1163–1176.
- Moir, D. R.** 1954. Beach ridges and vegetation in the Hudson Bay region. North Dakota Academy of Science Annual Proceedings 8: 45–48.
- Neal, M. W., and K. A. Kershaw.** 1973a. Studies on lichen-dominated systems. III. Phytosociology of a raised-beach system near Cape Henrietta-Maria, northern Ontario. Canadian Journal of Botany 51: 1115–1125.
- Neal, M. W., and K. A. Kershaw.** 1973b. Studies on lichen-dominated systems. IV. The objective analysis of Cape Henrietta-Maria raised beach systems. Canadian Journal of Botany 51: 1170–1190.
- Nordhagen, R.** 1954. Studies on the vegetation of salt and brackish marshes in Finmark (Norway). Vegetatio 5: 381–394.
- Persson, H., and H. Sjörs.** 1960. Some bryophytes from the Hudson Bay Lowland of Ontario. Svensk Botanisk Tidskrift 54: 247–260.

- Pielou, E. C., and R. D. Routledge.** 1976. Salt marsh vegetation: latitudinal gradients in the zonation patterns. *Oecologia* 24: 311–321.
- Porsild, A. E., and W. J. Cody.** 1980. Vascular plants of the continental Northwest Territories, Canada. National Museum of Natural Sciences, Ottawa, Ontario. 667 pp.
- Riley, J. L.** 1979. Some new and interesting vascular plant records from northern Ontario. *Canadian Field-Naturalist* 93: 355–362.
- Riley, J. L., and S. M. MacKay.** 1980. The vegetation and phytogeography of coastal southwestern James Bay. Royal Ontario Museum, Toronto, Ontario, Life Science Contribution Number 124. 81 pp.
- Ringius, G. S.** 1980. Vegetation survey of a James Bay coastal marsh. *Canadian Field-Naturalist* 94: 110–120.
- Ritchie, J. C.** 1957. The vegetation of northern Manitoba. II. A prisere on the Hudson Bay Lowlands. *Ecology* 38: 429–435.
- Rouse, W. R., and K. A. Kershaw.** 1973. Studies on lichen-dominated systems. VI. Interrelations of vegetation and soil moisture in the Hudson Bay Lowlands. *Canadian Journal of Botany* 51: 1309–1316.
- Schofield, W. B.** 1959. Pp. 107–132 in The salt marsh vegetation of Churchill, Manitoba, and its physiographic implications. National Museum of Canada Contributions to Botany, Bulletin Number 60.
- Sims, R. A., J. L. Riley, and J. K. Jeglum.** 1979. Vegetation, flora and vegetational ecology of the Hudson Bay Lowland: a literature review and annotated bibliography. Department of the Environment, Canadian Forestry Service, Sault Ste. Marie, Ontario, Report O-X-297. 177 pp.
- Sims, R. A., D. W. Cowell, and G. M. Wickware.** 1982. Classification of fens near southern James Bay, Ontario, using vegetational physiognomy. *Canadian Journal of Botany* 60: 2608–2623.
- Stotler, R., and B. Crandall-Stotler.** 1977. A checklist of the liverworts and hornworts of North America. *Bryologist* 80: 405–428.
- Webber, P. J., J. W. Richardson, and J. T. Andrew.** 1970. Post-glacial uplift and substrate age at Cape Henrietta-Maria, southeastern Hudson Bay, Canada. *Canadian Journal of Earth Sciences* 7: 317–325.
- Wickware, G. M., D. W. Cowell, and R. A. Sims.** 1981. Peat resources of the Hudson Bay Lowland coastal zone. Pp. 138–143 in *Proceedings of the Sixth International Peat Congress*, Duluth, Minnesota.

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Bird Kill at an Oil Industry Flare Stack in Northwest Alberta

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Approximately 3000 migrating passerines died within 75 m of a 104 m oil industry flare stack in northwestern Alberta during late May 1980. The birds died during a period of unsettled weather including periods of rainfall, cloud, fog, and reduced temperature. All identified birds were passerines and included five families and at least 24 species. The presence of pulmonary congestion and edema in specimens examined and the proximity of the birds to the flare stack suggested deaths may have been related to stack emissions. Examination of specimens indicated that death from striking the tower or guy wires, burning in the flare, or toxic agents (contacted previously) was unlikely for the majority of the casualties. Recommendations to minimize the occurrence of bird kills at flare stacks and to assist in documenting the occurrence and significance of such mortalities include processing and selling sour gas rather than flaring, mandatory reporting of bird kills at industry flare stacks, contingency plans to ensure quick and thorough analysis of dead birds and increased evaluation of methods used to detect traces of gaseous irritants in animals.

Key Words: Bird kill, passerines, Alberta, flare stack.

Many accounts of mortality of migrating passerines at man-made obstacles have been documented (Weir 1976). The most common sites of these mortalities were television and radio towers (Gollop 1965; Stoddard and Norris 1967; Kale et al. 1969), tall floodlights (James 1956), and airport ceilometers (Howell et al. 1954). Such mortalities are most commonly reported during spring and fall migrations and inclement weather (Howell et al. 1954; James 1956; Lack 1960; Kemper et al. 1966; Stoddard and Norris 1967; Kale et al. 1969; Weir 1976; Avery et al. 1978).

Despite numerous gas and oil industry flare stacks throughout various areas of North America, there have been few documentations of bird kills at these sites (Weir 1976; Avery et al. 1978). This paper summarized details of the deaths of nearly 3000 passerines at a flare stack in northwestern Alberta during May 1980.

Background and Methods

The flare stack where the birds died was located southwest of Lesser Slave Lake in northwestern Alberta (near 55°12'N, 117°24'W). The flare stack was part of a Battery "O" 2 Group Separator. Here oil was separated from sour gas, primarily hydrogen sulfide (H_2S), and the H_2S was burned in the flare stack, yielding sulfur dioxide (SO_2) as the main by-product. The flare stack was 104.4 m tall by 10 cm in diameter and was equipped with an automatic ignitor and burning pilot. The stack was anchored by 21 guy wires. Each wire originated on the stack and was anchored to the ground at one of three locations, about 100 m away from the stack.

The battery had been in operation since 1958, but the 104.4 m stack was not installed until June 1978. During September 1980, new equipment was installed, allowing the majority of the sour gas to be separated and sold. Between June 1978 and September 1980 the flare normally burned continuously with the flame extending approximately 10 m beyond the top of the stack.

The flare stack was located on a prominent ridge (Puskwaskau Hills) at 762 m elevation. Dominant vegetation of the area about the site includes Trembling Aspen, *Populus tremuloides*, and White Spruce, *Picea glauca*. Prevailing winds are from the northwest.

The finding of dead birds at the flare stack was reported to Alberta Fish and Wildlife Division personnel on 28 May 1980. The site was inspected the same day and 16 specimens were randomly collected and frozen. The following day the author investigated the site. On that morning (according to oil industry employees at the site) the majority of the birds had been gathered up and dumped into a barrel. An attempt to burn the birds was largely unsuccessful; many of them were not burned. Subsequently, all birds in the barrel were counted, placed in plastic bags, and frozen.

Birds were identified with the assistance of the Ornithology Program, Provincial Museum of Alberta, Edmonton, Alberta. Only specimens not severely burned were identified. Sixteen specimens collected the day of discovery were submitted to specialists in the Veterinary Services Division, Alberta Agriculture, Airdrie, Alberta for necropsy. Tissues from these specimens were examined by

toxicologists at the Environmental Research Laboratory, Alberta Environment, Vegreville, Alberta. An additional 40 specimens were analyzed jointly by Alberta Veterinary Services Division, Alberta Agriculture, Edmonton, Alberta, and the Pesticides and Chemicals Branch, Alberta Environment, Edmonton, Alberta, for pesticides, herbicides, and other agents.

Employees at the flare stack were interviewed for details of this bird kill. Six transects, 3 m wide by 75 m

long, radiating from the flare stack were walked to determine locations of dead birds in relation to the stack. This detected only birds missed when the majority were picked by the oil industry personnel. Dead birds found were counted and their locations plotted. The entire area between 75 m and 200 m radius of the flare stack was thoroughly searched for dead birds.

Weather records were made available from the Alberta Forest Service Weather Office, Edmonton,

TABLE 1. Identification of birds killed at an oil industry flare stack in northwestern Alberta during May 1980.

Family	Species	Number		
		Retrieved	Necropsy	Toxicology
Tyrannidae	Flycatcher, <i>Empidonax</i> spp.	20	—	—
	Unidentified flycatcher	7	—	—
	TOTAL	27	0	0
Muscicapidae	Swainson's Thrush, <i>Catharus ustulatus</i>	7	1	3
	Unidentified thrush	16	—	—
	TOTAL	23	1	3
Vireonidae	Red-eyed Vireo, <i>Vireo olivaceus</i>	22	—	1
	Unidentified vireo	23	—	—
	TOTAL	45	0	1
Emberizidae	Tennessee Warbler, <i>Vermivora peregrina</i>	49	4	—
	Yellow Warbler, <i>Dendroica petechia</i>	282	3	—
	Magnolia Warbler, <i>Dendroica magnolia</i>	6	—	—
	Yellow-rumped Warbler, <i>Dendroica coronata</i>	29	—	—
	Bay-breasted Warbler, <i>Dendroica castanea</i>	4	—	—
	Blackpoll Warbler, <i>Dendroica striata</i>	143	1	20
	Black-and-white Warbler, <i>Mniotilta varia</i>	12	—	—
	American Redstart, <i>Setophaga ruticilla</i>	55	2	—
	Ovenbird, <i>Seiurus aurocapillus</i>	9	1	—
	Northern Waterthrush, <i>Seiurus noveboracensis</i>	5	—	—
	Mourning Warbler, <i>Oporornis philadelphia</i>	5	—	—
	Common Yellowthroat, <i>Geothlypis trichas</i>	11	—	—
	Western Tanager, <i>Piranga ludoviciana</i>	2	—	—
	Rose-breasted Grosbeak, <i>Pheucticus ludovicianus</i>	9	—	3
	Chipping Sparrow, <i>Spizella passerina</i>	2	—	—
	Clay-colored Sparrow, <i>Spizella pallida</i>	3	1	—
	Savannah Sparrow, <i>Passerculus sandwichensis</i>	5	—	—
	White-throated Sparrow, <i>Zonotrichia albicollis</i>	79	2	13
	White-crowned Sparrow, <i>Zonotrichia leucophrys</i>	2	—	—
	Northern Oriole, <i>Icterus galbula</i>	2	1	—
	Unidentified Warbler	530	—	—
	Unidentified Sparrow	50	—	—
	Unidentified Oriole	1	—	—
	TOTAL	1295	16	36
Fringillidae	Evening Grosbeak, <i>Coccothraustes vespertinus</i>	3	—	—
	TOTAL	3	0	0
TOTAL IDENTIFIED		1393	16	40
UNKNOWN		93	0	0

TABLE 2. Location of birds killed at an oil industry flare stack in northwestern Alberta during May 1980 in relation to the flare tower.

Transect Number ¹	Distance from Flare Stack (m)				Direction from flare stack (degrees)
	0-25	36-50	51-75	75-200	
	ontransect			offtransect	
1	24	13	12	—	28
2	7	0	0	—	64
3	16	16	7	—	132
4	11	5	4	—	208
5	5	6	1	—	244
6	5	3	0	—	312
Total birds	68	44	24	1	
	(49.6) ²	(32.1)	(17.5)	(0.7) ³	

¹All transects were 3 m × 75 m.

²(Percent). These figures include only birds which remained after initial cleanup.

³The entire area between 75 m and 200 m was intensively searched.

Alberta, for Puskwaskau Tower located 3 km northeast of the flare stack.

Results

Numbers, Dates, Species, and Locations

Dates between site inspections indicated the majority of the birds died between late afternoon 26 May and 20:00 h 28 May 1980. Specimens counted and collected numbered 2318, an additional 240 birds were counted but not collected, and an estimated 500 birds were observed but not counted. Industry staff employed at the site indicated that about 100 dead birds had accumulated beneath the stack during the week prior to 26 May 1980. Birds identified to family numbered 1393; of these, 746 were identified to species. All birds were passerines and included five families and at least 24 species (Table 1). All commonly migrate at night (Weir 1976). Wood warblers (Family *Emberizidae*) constituted 77% of all identified birds. The most common were Yellow and Blackpoll warblers (Scientific names in Table 1). All identified birds were mature, and sex ratios, when determined, varied with species.

All but one of the dead birds were found within 75 m of the flare stack (Table 2). Observations of dead birds located on six transects (3 m by 75 m), which radiated outward from the flare stack, showed that 81.7% were within 50 m of the stack. An intensive search for dead birds between 75 and 200 m from the flare stack located only one Yellow Warbler, approximately 85 m due east of the flare stack.

Weather

The birds died during a period of generally unsettled weather including rainfall, cloud, fog and reduced temperatures (Table 3). Specifically, fog and

continuous light rain and reduced temperatures were observed at the Puskwaskau Forestry Tower (3 km northeast of the flare stack) on the afternoon of 26 May, morning and afternoon of 27 May, and morning of 28 May 1980. Winds were from the NE, NW, N, and W, varying from 13 to 17 km/h.

Laboratory Analysis

Laboratory analysis consisted of necropsy, and histological and toxicological investigations. Sixteen specimens (see Table 1) were necropsied by Provincial veterinary poultry specialists. All appeared in good flesh with considerable subcutaneous fat over the abdomen; all stomachs were empty. Considerable congestion and edema of the lungs occurred in all birds. The breast musculature of all birds was dark and congested. A faint "paint-like" odor was detected from the Northern Oriole, one American Redstart, one Tennessee Warbler, and the Ovenbird. None of the submitted birds had broken appendages. Histological examination of heart and lung tissue was inconclusive; the tissue had been frozen previously and some autolysis was apparent.

Fat, gizzard, and feathers of 40 specimens of five species (Table 1) were analyzed for toxic agents. Traces of most pesticides found were isolated from fat and gizzard samples but not from feathers. Analysis for strychnine in liver samples of one Rose-breasted Grosbeak, one Swainson's Thrush, and one Blackpoll Warbler indicated no strychnine was present. Details of pesticide analysis will be reported later.

Discussion, Conclusions, and Recommendations

Records of migrating passerines (primarily warblers) being attracted to bright light sources during periods of low clouds, fog and rain have been

well documented (Clarke 1912; James 1956; Weir 1976; Avery et al. 1978). Lack (1960) observed that night migrants often travel at low elevations during periods of inclement weather. Howell et al. (1954) suggested that on nights of low cloud ceiling, night migrants were attracted by vertical beams of light reflecting off the base of the clouds. They also observed that once the birds were attracted to the light source and passed within the beam, they suffered temporary disorientation. Davies (1940) and Stoddard and Harris (1967) observed passerines "fluttering like moths" in disorientation about a gas flare and an airport ceilometer, respectively. In this study, considering the time of year, numbers of birds killed, and time frame, it is likely that the majority of birds were migrating north to their summering areas. All birds killed were primarily night migrants (Weir 1976) and are resident in Alberta only during summer. Also, considering the inclement weather, the fact that the flare stack was on a prominent hill, and that the dead birds were found immediately about the flare stack, it is likely that the migrating birds were attracted to the flare stack and subsequently killed. However, the precise cause of death was not apparent.

The most common causes of bird deaths recorded in other studies included collision with stationary

objects or other birds (Davies 1940; Howell et al. 1954; James 1956; Newman 1960; Stoddard and Norris 1967; Weir 1976). To determine whether birds in our investigation died as a result of collisions, the physical condition of our specimens was compared with reports in the literature. Stoddard and Norris (1967) reported that birds which had struck solid objects were commonly found with brain injury as indicated by a blood clot in the brain. Howell et al. (1954) also reported that head injuries, including broken mandibles, were common. Birds killed as a result of collisions with stationary objects and prepared at the Alberta Provincial Museum often have split or broken mandibles or a spot of bare feathers on the back or side of the neck (P. Stepney, personal communication). James (1956) reported broken necks as common injuries.

In this study, none of the 56 specimens examined by veterinary pathologists had broken mandibles, appendages, or other skeletal damage. Brain damage could not be determined due to autolysis. Necropsies revealed hemorrhaging in breast musculature of a few individuals. Therefore, collision appeared unlikely to be a cause of death for these birds. Of birds sent to the Provincial Museum in Edmonton for examination, about 5% had skeletal damage including cracked

TABLE 3. Weather trends from Alberta Forest Service, Puskwaskau Tower¹, in northwestern Alberta, 13 May — 14 June 1980.

Date:	13-25 May	26 May	27 May	28 May	29 May - 14 June
Weather conditions ²					
0700	haze—no significant weather—fog—drizzle—rain	drizzle ground fog	drizzle and fog	fog	no significant weather fog—rain showers—no significant weather
1300	haze—no significant weather—fog—rain—drizzle	rain showers and fog	fog	no significant weather	no significant weather—rain showers—no significant weather
Temperature ⁴ (C°)					
0700	7.6	4	3	5	7.9
1300	13.9	4	3	9	14.1
Relative humidity (%)					
0700	78.4	100	100	100	83.9
1300	56.9	100	100	72	64.8
Windspeed (km/h)					
0700	11.7	W 15	NE 16	W 10	14.1
1300	12.7	NE 13	N 15	NW 17	10.8
Precipitation (mm)					
0700	2.4	0.5 ³	1.5 ³	0.5 ³	1.1
1300	1.3	6.0 ³	0.9	0.5 ³	0.1

¹Tower located 3 km from the flare stack.

²Summarized weather conditions before, during and after the bird kill.

³Continuous rain.

⁴Data shown for categories (before and after bird kill) are means.

mandibles and broken appendages (P. Stepney, personal communication). It is likely that many of these broken bones, particularly the appendicular ones, occurred as a result of the initial clean-up by oil industry personnel.

Of the 240 birds examined by the author which had been missed during the original clean-up (and thus were not placed in the barrel where burning was attempted), there was no evidence of burned feathers, indicating that direct contact with the flare was not responsible for death.

Death could have been related to emissions from the flare stack. Casarett and Doull (1980) indicated that common signs of hydrogen sulfide poisoning in animals included irritation of the respiratory tract and pulmonary edema. The pulmonary congestion and edema of birds examined in this study and the proximity of the dead birds to the flare stack (which emitted SO_2 and H_2S) suggests that the deaths may have been related to the emissions. Tests for abnormal levels of sulfur in tissues were not conducted, as no fresh samples were available for evaluation (the 16 specimens collected when fresh had been frozen 10 days prior to examination) and precise procedures were not available to conduct such evaluation on birds.

This paper has summarized the first reported major occurrence of the death of a large number of migrating passerines at an oil industry flare stack in Canada. It is not known if this incident was unique. Several unsubstantiated cases of deaths of large numbers of birds at flare stacks have been reported to the author. To minimize the occurrence of bird kills at flare stacks and to enhance the documentation, the following steps should be considered: (1) industry should be required to report major incidents of bird kills at flare stacks to appropriate authorities as a requirement of permits or licences; (2) whenever possible, sour gas should be processed and sold or otherwise treated, rather than flared; (3) wildlife management agencies should have contingency plans to ensure that once bird kills are reported, the specimens are processed immediately to determine cause of death; (4) research into methods of detecting traces of gaseous irritants in animals should be pursued.

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Literature Cited

- Avery, M. L., P. F. Springer and N. S. Dailey. 1978. Avian mortality at man-made structures: an annotated bibliography. United States Fish and Wildlife Service, Washington D.C. 108 pp.
- Casarett, S., and J. Doull. 1980. Toxicology: the basic science of poisons. Second edition. Macmillan Publishing Co., New York, New York.
- Clarke, W. E. 1912. Studies in bird migration. Geuney and Jackson, London, England.
- Davies, W. B. 1940. Gas flares and birds. *Condor* 42: 127.
- Gollop, M. A. 1965. Bird migration collision casualties at Saskatoon. *Blue Jay* 23: 15-17.
- Howell, J. C., A. R. Laskey, and J. T. Tanner. 1954. Bird mortality at airport ceilometers. *Wilson Bulletin* 66: 207-215.
- James, P. 1956. Destruction of warblers on Padre Island, Texas, in May 1951. *Wilson Bulletin* 68: 224-227.
- Kale, H. W., M. H. Hundley, and J. A. Tucker. 1969. Tower-killed specimens and observations of migrant birds from Grand Bahama Island. *Wilson Bulletin* 81: 258-263.
- Kemper, C. A., D. G. Raveling, and D. W. Warner. 1966. A comparison of the species composition of two T.V. tower-killed samples from the same night of migration. *Wilson Bulletin* 78: 26-30.
- Lack, D. 1960. The influence of weather on passerine migration. A review. *Auk* 77: 171-209.
- Newman, R. J. 1960. Spring migration — Central Southern Region. *Audubon Field Notes* 14: 392-397.
- Stoddard, H. L., and R. A. Norris. 1967. Bird casualties at a Leon County, Florida T.V. tower: an eleven year study. *Tall Timbers Research Station Bulletin* 8: 1-104.
- Weir, R. D. 1976. Annotated bibliography of bird kills at man-made obstacles. A review of the state of the art and solutions. Canadian Wildlife Service Report E CWSC2483, Ottawa, Canada.

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Brood Size and Chick Position as Factors Influencing Feeding Frequency, Growth, and Survival of Nestling Double-crested Cormorants, *Phalacrocorax auritus*

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This study examines brood size and chick position in the hatching sequence as factors influencing the feeding frequency, growth and mortality of 34 Double-crested Cormorant chicks (*Phalacrocorax auritus*) constituting 13 broods of a tree-nesting colony at Îles de la Madeleine, Québec. Growth curves of chicks weighed approximately every three days were fitted to the Gompertz equation. Although the mean final weight, the number of feeding periods and number of daily foraging trips tended to increase with increasing brood size and declining average growth rate and individual feeding frequency, those relationships were not statistically significant. This suggests that breeding Double-crested Cormorants of that colony adjust the amount of food they bring to the nest from each foraging trip according to brood size, and that chicks are fed the same amount of food irrespective of brood size. Final weights, growth rates, meal size and feeding frequency of individual chicks did not seem to vary as a function of their position in the hatching sequence. There was not a higher mortality in chicks hatched last in a brood than in those hatched earlier, but all nestlings that died did so within a few days after hatching. Consequently, there is no evidence that a chick hatched last in a brood survives less well than those hatched earlier.

Key Words: Double-crested Cormorant, *Phalacrocorax auritus*, brood size, order of hatch, feeding frequency, nestling growth, mortality.

Cette étude porte sur les effets de la taille de la nichée et du rang de naissance sur la fréquence d'alimentation, la croissance et la mortalité de 34 jeunes Cormorans à aigrettes (*Phalacrocorax auritus*) appartenant à 13 nichées d'une colonie arboricole des îles de la Madeleine, Québec. Les courbes de croissance des poussins pesés à tous les trois jours environ ont été ajustées à l'équation de Gompertz. Bien que l'on constate une tendance à l'effet que le poids final moyen, le nombre de périodes d'alimentation et celui des voyages de pêche augmentent avec la taille de la nichée alors que le taux moyen de croissance et la fréquence individuelle d'alimentation diminuent, ces relations ne se confirment pas statistiquement. De fait, nous croyons que les Cormorans à aigrettes des îles de la Madeleine ajustent à la taille et aux besoins de la nichée le volume de proies qu'ils rapportent de chaque voyage de pêche et que les poussins reçoivent la même quantité de nourriture, peu importe leur nombre au sein de la nichée. Il ne semble pas non plus que le poids final, le taux de croissance et la fréquence d'alimentation de chacun des poussins varient en fonction de leur rang de naissance. Les données ne permettent pas d'affirmer que la mortalité est plus élevée chez les derniers-nés, mais, lorsqu'elle se manifeste, elle suit de peu de jours la naissance. En conséquence, rien ne porte à croire que le dernier-né d'une nichée ait une taux de survie plus faible que celui des aînés.

Mots clés: Cormoran à aigrettes, *Phalacrocorax auritus*, taille de la nichée, rang de naissance, fréquence d'alimentation, croissance des poussins, mortalité.

Chick growth of Double-crested Cormorants (*Phalacrocorax auritus*) and other phalacrocoracids has been the subject of many studies in the past (e.g. Mendall 1936; Snow 1960, 1963; Nelson 1964; Pearson 1968; Ricklefs 1968, 1973; Robertson 1971; Dunn 1975a, 1975b; Cleary 1977; Mitchell 1977; DesGranges 1982). Only Mitchell (1977) has given details of growth in tree-nesting cormorants. In a tree-nesting colony, high winds can damage nests and even break down nest-bearing trees and dislodge nests and their contents. In theory, in comparison with ground-nesting birds, tree-nesting cormorants should devote more time to repairing their nests and spend less time in foraging. Individual chicks of larger broods will be

fed less food unless their parents adjust their rate of provisioning to the number of chicks. Asynchronous hatching of eggs (Palmer, 1962) may result in better feeding opportunities for the first-hatched than the last-hatched chick (Selective starvation; O'Connor, 1978). Most authors have discussed growth rates and feeding frequency as a function of brood size and chick position in hatching sequence, but results disagree: Snow (1960), Robertson (1971), DesGranges (1982) and Dunn (1975a) did not see any significant relationship between growth rate or feeding frequency and brood size or chick position; Nelson (1964) and Cleary (1977) got opposite results. Very little information bears on chick feeding

frequency; Snow (1963), Pearson (1968), Robertson (1971) and Dunn (1975a) examined food delivery rates to chicks, but did not distinguish between members within a brood (siblings).

This study relates chick growth, feeding frequency and mortality to brood size and hatch-order of the chick in a tree-nesting colony of Double-crested Cormorants on the Iles de la Madeleine archipelago, Quebec. The role of male and female parents in nest attendance and care of young is treated elsewhere (Léger 1984; Léger and McNeil 1985).

Study Area

The Iles de la Madeleine Archipelago is located in the Gulf of St. Lawrence between 47° 13' and 47° 39' N, and between 61° 23' and 62° 01' W. Double-crested Cormorants (1940 pairs in 1980) breed in a mixed colony with Great Blue Herons (*Ardea herodias*) on Ile aux Loups Marins, a 14 ha wooded island (*Abies balsamea* and *Picea glauca*) located in the Grande-Entrée lagoon. Great Black-backed (*Larus marinus*) and Herring (*L. argentatus*) gulls also breed on this island. See Léger (1984) for details.

Methods

The feeding frequency of nestlings was studied through observation of 10 broods from a blind 7 m high. These consisted of one 1-chick brood (after the death of two last-hatched siblings), five 2-chick broods (including one brood after the death of the first-, second- and third-hatched chick and two after that of the third-hatched), two 3-chick broods (after the death of the fourth- and fifth-hatched chick in one nest and the death of the first-hatched in the other) and two 4-chick broods (including one after the death of the fifth-hatched chick). Observations (total 165 h) were made during eleven 15 hour periods (05:30–20:30) at 5 day intervals between 12 June and 6 August 1980. Once chicks were 20 days old, they were individually distinguishable from the blind by a colored ribbon put on one leg a few hours after hatching and by a numbered, colored metal band affixed when they reached 20 days. Earlier, the chicks were too small and inactive for the ribbons to be seen.

Thirty-four chicks constituting 13 broods (10 broods mentioned above plus one 2-chick, one 3-chick, and one 4-chick brood) were weighed (Pesola

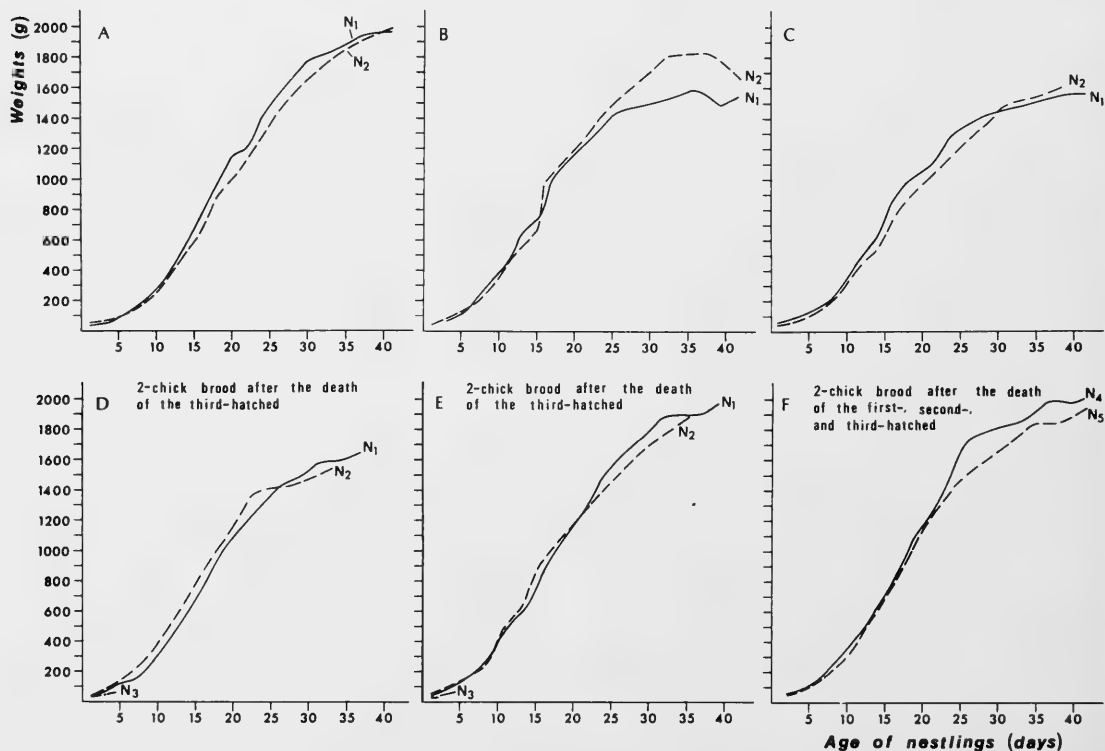


FIGURE 1. Individual growth curves for nestlings of two-chick broods of Double-crested Cormorants of Ile aux Loups Marins. N1, N2, N3 and N4 indicate the order of hatch.

scales: $0-100 \pm 1$ g, $0-300 \pm 2$ g, $0-2000 \pm 25$ g) between 09:00 and 10:00 at 3 day intervals between hatching and fledging. It was not practicable to weigh chicks at night, as Coulter (1981) suggested, as a means of avoiding variations in weight of undigested food.

Meal weights were estimated in one 2-chick brood (i.e. in chicks 4 and 5 after the early death of chicks 1, 2 and 3); chicks were weighed before and after being fed by their parents, on ten occasions between 25 June and 25 July 1980.

The average growth curve for body weights of the 34 chicks that fledged and the individual growth curve of every chick were fitted to the Gompertz equation (see Ricklefs 1968, 1973 for details). Our data do not conform closely to the logistic and Von Bertalanffy equations, often used to describe quantitatively the components of the growth patterns of young birds (Ricklefs 1967; Mineau et al. 1982). The logistic, Gompertz and Von Bertalanffy equations were tested by nonlinear adjustment through the use of a regression program (Marguardt's method) available on the SPSS package (Nie et al. 1975; Robertson 1977).

Comparisons of the asymptotes (final weights) and mean growth rates of chicks of different brood sizes and orders of hatch were done using multidimensional variance analysis (MANOVA) (Sokal and Rohlf 1981). We also calculated Spearman's coefficients of rank correlation (Siegel 1956) to verify whether or not there was a linear relationship between mean feeding frequency and growth rate and between mean feeding frequency and asymptotic weight of chicks. Comparisons of the meal sizes and feeding frequencies of chicks as a function of the order of hatch or the brood size have been done through U-Mann-Whitney, Wilcoxon and Friedman tests, respectively equivalent to Student *t*-, paired Student *t*-tests, and variance analysis with classification criteria (see Siegel 1956).

Results

Mean Growth Curve

The mean growth curve for weights of fully-fledged young Double-crested Cormorants of Ile aux Loups Marins is sigmoid in form (see Figures 1, 2 and 3). At hatching, chicks weighed, on average, 34.7 ± 2.96 g, a weight equal to 1.8% of mean adult weight (1921.7 ± 224.1 g, $N = 18$; see Léger and Burton 1979). The asymptote of the mean growth curve is 1889.4 g (98% of the mean adult weight), while the mean asymptote of the 33 individual growth curves equals 1900.5 ± 189.8 g (99% of the mean adult weight). The growth

rate of the mean growth curve (KG or constant K of the Gompertz equation) equals 0.116; the mean of the 33 individual growth curves is 0.120 ± 0.017 .

Growth Rate and Asymptote in Relation to Brood Size

Table 1 gives values of asymptotes and average growth rates of 2-, 3-, and 4-chick broods. Although the average asymptote tends to increase with increasing brood size and declining average growth rate (see Table 1), the multidimensional variance analysis (MANOVA) indicates the differences to be statistically insignificant ($F = 0.236$, $P > 0.05$; $F = 0.572$, $P > 0.05$), probably owing to small sample sizes.

Growth and Feeding Frequency

The average feeding frequency (mean number of single feeds/chick/hour or day) of all chicks during the entire chick-rearing period did not seem to significantly affect growth rates and asymptotes (R_s for growth rates = -0.287 , $N = 24$, $P > 0.05$; R_s for asymptote = 0.336 , $N = 25$, $P > 0.05$).

Feeding Frequency in Relation to Brood Size

Figures 4B and 4C show, as a function of the age of the brood, the variations of the number of daily feeding periods or meals and foraging journeys, considering, on the one hand, 1- and 2-chick broods, and, on the other, 3- and 4-chick broods. The curve for 3- and 4-chick broods averages higher than the other one and indicates that efforts of parents to feed the young increase with brood size. However, U-Mann-Whitney tests (Léger 1984) for each of the twelve 5-day intervals of the brooding period indicate that these numbers are significantly higher in 3- and 4-chick broods than in 1- and 2-chick broods, only between 21 and 25 days of age ($U = 2$, $P < 0.05$; $U = 0.00$, $P < 0.001$).

Figure 4A shows the variations of the individual feeding frequency of chicks from 1-, 2-, 3-, and 4-chick broods as a function of the age of the brood. With the exception of the 1-chick brood, that frequency seems to decline with increasing brood size. It was not possible to measure in a regular manner the real individual feeding frequency for every chick during their first 20 days following hatching (see Methods). To avoid that difficulty, we calculated, for each 5-day interval following hatching, what we call the estimated individual frequency, that is, the number of feeding periods or meals/hour divided by the number of chicks in the brood. U-Mann-Whitney tests (Léger 1984) used for comparing the means of actual and estimated individual feeding frequencies of chicks from 1- and 2-chick versus 3- and 4-chick broods for each of the twelve 5-day intervals indicate a significant decrease in estimated and actual frequencies as a

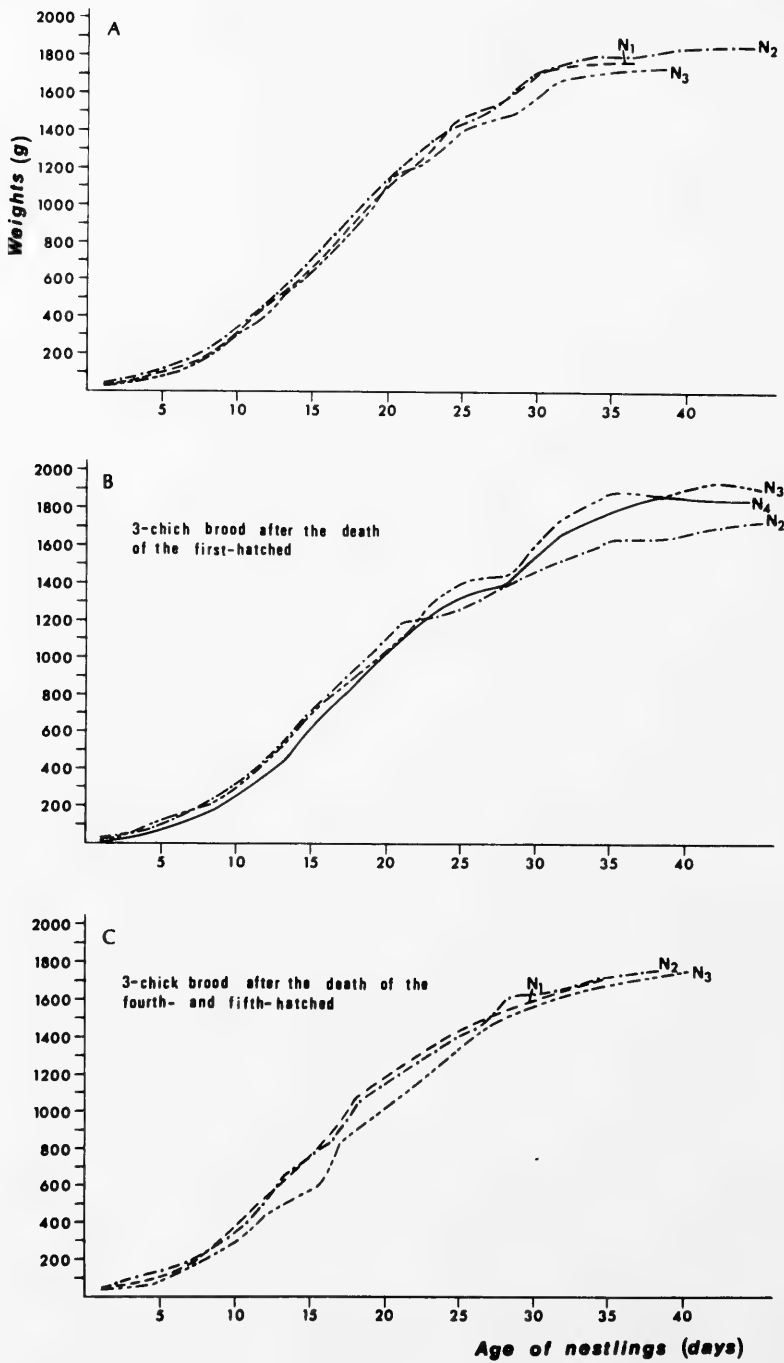


FIGURE 2. Individual growth curves for nestlings of three-chick broods of Double-crested Cormorants of Ile aux Loups Marins. For explanations of the figure, see Figure 1.

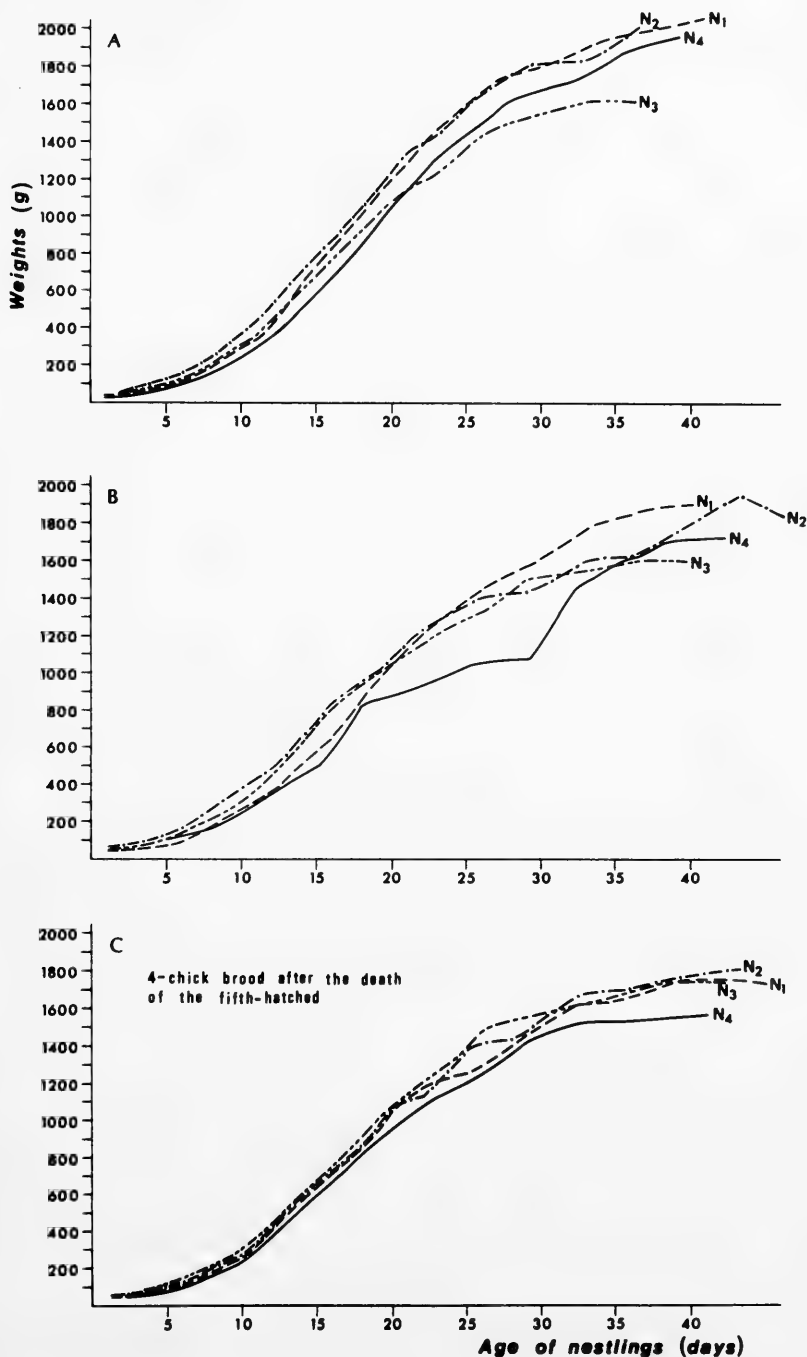


FIGURE 3. Individual growth curves for nestlings of four-chick broods of Double-crested Cormorants of Ile aux Loups Marins. For explanations of the figure, see Figure 1.

TABLE 1. Mean asymptotes and growth rates of nestling Double-crested Cormorants of Ile aux Loups Marins as a function of the brood size and the order of hatch.

Brood size	Order of hatch	Asymptote (g)*			Growth rate (KG)**	
		N	\bar{X}	S.D.	\bar{X}	S.D.
2 chicks	chick 1	6	1849.5	256.6	0.128	0.016
	2	6	1890.8	203.4	0.117	0.017
	Total	12	1870.2	221.8	0.123	0.016
3 chicks	chick 1	3	1844.0	83.1	0.120	0.006
	2	3	1944.0	105.3	0.116	0.010
	3	3	1905.7	65.4	0.115	0.004
	Total	9	1898.1	86.6	0.117	0.006
4 chicks	chick 1	3	1968.0	196.9	0.113	0.013
	2	3	2019.0	165.4	0.116	0.004
	3	3	1807.7	124.9	0.112	0.009
	4	3	2010.0	350.3	0.104	0.035
	Total	12	1949.8	213.4	0.114	0.018
All broods combined		33	1900.5	189.8	0.120	0.017
Mean growth curve			1889.4		0.116	

*Asymptote A (final weight) of the Gompertz equation.

**KG = constant K of the Gompertz equation.

function of brood size only when young are between 31 and 40 days of age ($U = 23.5$, $P < 0.001$; $U = 1.5$, $P < 0.05$; $U = 14.9$, $P < 0.001$; $U = 0.0$, $P < 0.01$), and between 46 and 50 days of age for the actual frequency ($U = 34.5$, $P < 0.01$).

Growth Rate and Asymptote in Relation to Order of Hatch

Eggs of a brood hatched at intervals from a few hours to 5 days ($\bar{X} = 1.59 \pm 1.19$ days). Figures 1, 2 and 3 show individual growth curves for weights of young of 2-, 3- and 4-chick broods. Chick position in the brood was determined by the order of hatch and the initial status of the brood (e.g. a 2-chick brood after the death of the first, second, and third-hatched chicks; see Figure 1F).

The growth curves of 2-chick broods (Figure 1), taking into account only fully-fledged birds, show within-brood and between-brood variations in growth rates and values of asymptotes. Sometimes the oldest chick, sometimes the youngest grew at a faster rate. In the 3- and 4-chick broods (Figures 2 and 3), the last chick to hatch often grew slightly more slowly than those hatched earlier, whether or not one or more siblings died before the fledging of survivors. In one case (Figure 2B), the last-hatched chick grew faster than all siblings that survived to 20 days of age. However, asymptotes and growth rates (Table 1) did not vary significantly (MANOVA, $P > 0.05$) with the order of hatch, nor did they seem to vary as a function of the degree of difference in age of chicks in a brood ($R_s < 0.208$ and 0.05 ; $P > 0.05$).

Feeding Frequency in Relation to Order of Hatch

Tests for non-parametric comparison (Wilcoxon and Friedman) do not show significant differences ($P > 0.05$) between individual feeding frequencies as a function of the position of the young as determined by the hatching sequence in 2-, 3- and 4-chick broods (Table 2).

Chick Meal Size and Order of Hatch

In chicks 4 and 5 (after the death of chicks 1, 2 and 3) for which meal sizes were estimated (Table 3), Wilcoxon tests do not show significant differences between meal sizes as a function of the order of hatch ($T = -11$, $N = 8$, $P > 0.05$). In the case of that brood (Fig. 1F), the last-hatched, however, grew at a slower rate and its asymptote was lower.

Mortality and Order of Hatch

Chick mortality appears to be highest in chicks hatched last in 3-chick broods (Table 4); in other cases (larger or smaller broods), there is no relation between the mortality rate and the order of hatch, but the sample size is too small to be meaningful. Of the 12 chicks that died before fledging, 11 died by day 12 and most only 2 to 5 days after hatching (Table 4).

Discussion

Relationship between Brood Size, Asymptote, Growth Rate and Feeding Frequency

The overall food requirements of a brood increase with its size but, as the number of daily foraging journeys and feeding periods tended to increase with brood size, the individual feeding frequency tended to

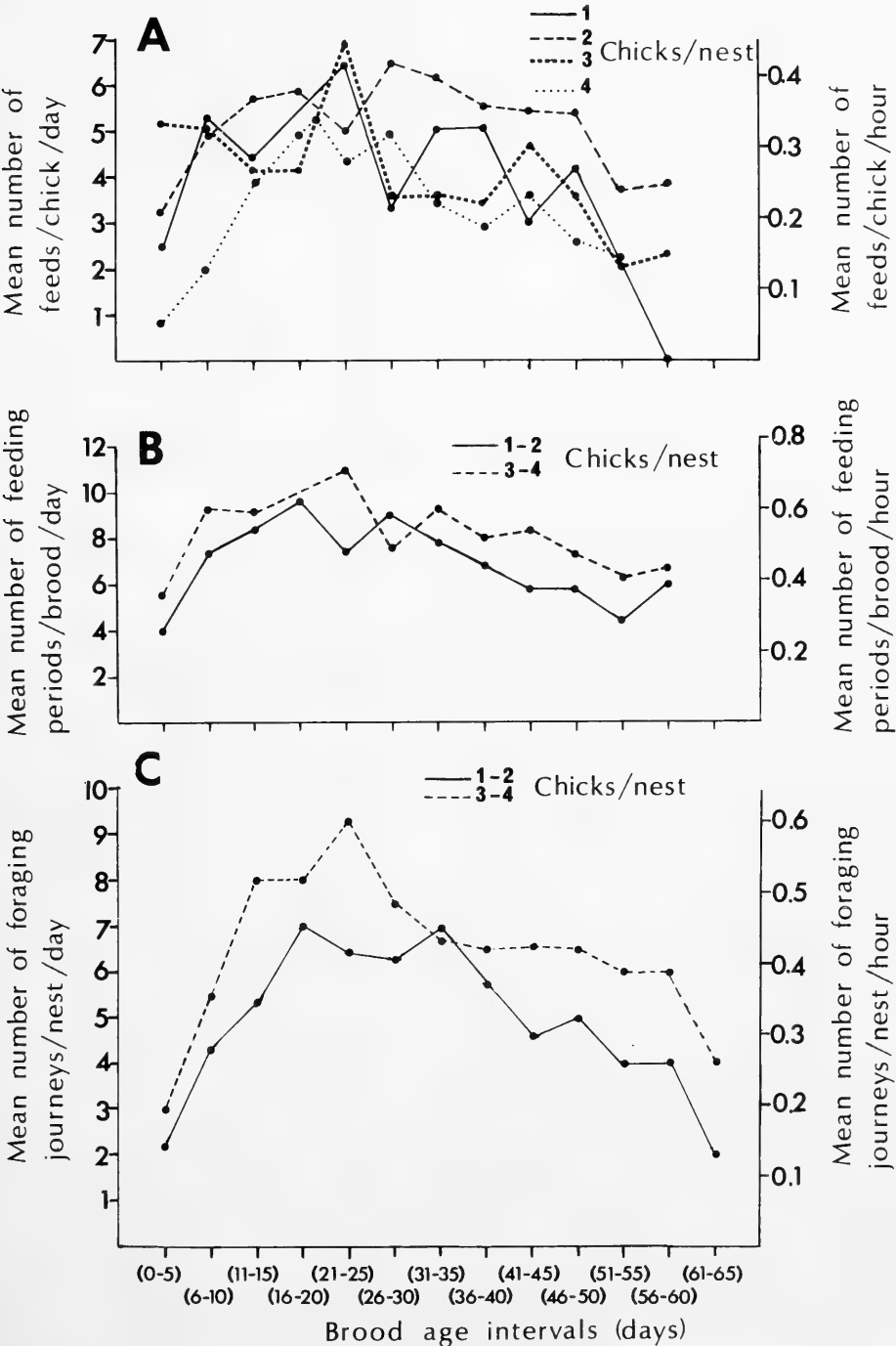


FIGURE 4. Variations, as a function of the age of the brood and brood size in Double-crested Cormorants, of the mean number (A) of single feeds/chick/day, (B) of feeding periods or meals/brood/day, and (C) of foraging journeys/nest/day.

TABLE 2. Mean value of daily actual individual feeding frequency of chicks, as a function of the order of hatch, in 2-, 3- and 4-chick broods of Ile aux Loups Marins Double-crested Cormorants.

Chicks/brood	Mean value of daily individual feeding frequency							
	First-hatched		Second-hatched		Third-hatched		Fourth-hatched	
	\bar{X}	S.D.	\bar{X}	S.D.	\bar{X}	S.D.	\bar{X}	S.D.
2	4.42	1.72	4.28	2.06				
2	5.28	2.75	5.00	1.91				
2	5.56	2.18	4.78	1.48				
2	5.37	1.85	4.63	2.06				
2	3.85	1.46	4.14	1.60				
3	3.29	2.14	2.71	1.60	3.43	1.62		
3	3.29	1.11	3.00	1.53	3.00	1.00		
4	4.14	1.34	4.43	2.15	4.28	1.80	4.86	1.46
4	2.40	0.89	2.40	0.89	1.80	0.84	1.00	1.22
Mean	4.30	1.90	4.02	1.87	3.23	1.58	3.25	2.38
	(N = 64)		(N = 64)		(N = 26)		(N = 12)	

decline. This corresponds with observations by Robertson (1971) in Double-crested and Pelagic cormorants (*P. pelagicus*) and by Pearson (1968) in the Shag (*P. aristotelis*) and Great Cormorant (*P. carbo*); however, none of our parameters varied significantly with brood size (except in a few of 5-day intervals during the brooding period). Our sample probably was too small to allow statistical confirmation of the apparent trends. Dunn (1975a) did not see any significant relationship between individual feeding frequencies and brood sizes of *P. auritus*. Nevertheless, she observed that young from 1-chick broods are fed more frequently than those of multi-chick nests.

Feeding frequency alone does not reflect the amount of ingested food (Dunn, 1975a); unfortunately, we do not have any result of the effects of brood size on the amount of ingested food. According to Ricklefs (1968), the asymptote is affected more by the variations of the feeding frequency and the volume of ingested food than by the growth rate. At Ile aux Loups Marins, the individual feeding frequency was not significantly correlated with chick growth rate and asymptotic weight, but the correlation coefficient between the asymptote and the mean feeding frequency of every chick approached statistical significance ($P = 0.051$).

One may question the validity of treating two chicks surviving from a brood of five as a 2-chick brood, since Coulson and Porter (1985) gave evidence for Black-legged Kittiwakes (*Rissa tridactyla*) that chicks from broods of three had higher growth rates and survival rates than those from broods either of two or one eggs. However, in the case of Ile aux Loups

Marins cormorants, we do not have any data permitting us to verify whether such a phenomenon occurs.

The average asymptote of Ile aux Loups Marins chicks tended to increase with increasing brood size and declining average growth rate; however, this is not statistically confirmed, probably because our sample was too small. According to Robertson (1971), Schreiber (1976), Cleary (1977) and DesGranges (1982), the asymptote and the rates of growth are not significantly affected by brood size. Cleary (1977) mentioned that the growth rates of 2-chick broods of *P. auritus* tended to be slower compared to smaller and larger ones. According to her data, parents that hatched only one or two of their eggs were probably less skilled and experienced in foraging than those which hatched three or four eggs, and therefore could not gather as much food for their young (or perhaps

TABLE 3. Meal weights of chicks 4 and 5 in a 2-chick brood (after early death of chicks, 1, 2 and 3) of Double-crested Cormorants.

Date	Age (days)		Meal weight (g)	
	Chick 4	Chick 5	Chick 4	Chick 5
25 June	7	5	5	10
30 June	12	10	25	20
3 July	15	13	65	40
4 July	16	14	100	10
8 July	20	18	100	125
8 July	20	18	25	50
10 July	22	20	75	50
19 July	31	29	75	25
21 July	33	31	—	65
25 July	37	35	50	—

TABLE 4. Mortality as a function of the order of hatch in nestling Double-crested Cormorants.

Brood size	Order of hatch	Number of nests	Number of chicks		Age at which chicks died (days)
			fledged	dead*	
1	1	1	0	1	41
2	1	3	3	0	—
	2		3	0	—
3	1	4	4	0	—
	2		3	1	2
	3		1	3	2, 2, 5
4	1	3	2	1	4
	2		3	0	—
	3		3	0	—
	4		3	0	—
5	1	3	2	1	3
	2		2	1	3
	3		2	1	3
	4		1	2	10, 12
	5		2	1	2
Totals		14	34	12	

*Before fledging.

they were merely birds with a lower parental quality overall; see Coulson and Porter 1985); in all 1-chick broods, irrespective of adult experience, parents succeeded in rearing young to fledging.

On the other hand, Nelson (1964) and Pearson (1968) found that growth rate declined with increasing brood size in the Shag and the Great Cormorant, respectively. Robertson (1971) observed a decreasing growth rate in Double-crested and Pelagic cormorants only when the number of siblings exceeded six (i.e. in supranormal broods). The absence of consensus among authors with respect to the effects of brood size on chick growth rate and asymptote of *Pelecaniformes* may be because studies were of different species, or because of regional and annual differences in the food supply (carrying capacity of the foraging habitat).

Robertson (1971) suggested that the feeding strategy of Double-crested and Pelagic Cormorants varies with prey abundance: when there is plenty of prey, as brood size increases a larger amount of food is brought back from each foraging trip; on the contrary, if there is a shortage of food, as brood size increases there is a larger number of foraging trips resulting in a higher energy expenditure. When food appears scarce, chick feeding frequency is higher but meal size is lower. In the case of the cormorants of Ile aux Loups Marins, the fact that young of 3- and 4-chick broods did not suffer any food shortage in comparison with smaller broods, and that the individual feeding frequency and foraging journeys

did not vary as a function of brood size, suggests that breeders adjust the amount of food they bring to the nest from each foraging trip according to brood size, and that chicks are fed the same amount of food irrespective of brood size.

Growth Rate, Asymptote, Feeding Frequency and Mortality in Relation to Order of Hatch

The growth rate, asymptote and feeding frequency of Ile aux Loups Marins cormorants did not vary significantly as a function of hatching sequence. In broods where 3 or 4 chicks approached fledging, the chick hatched last tended to grow at a lower rate than chicks 1 and 2; this suggests that competition between young may be stronger in 3- or 4-chick broods than in 1- or 2-chick nests, although the relationship was not statistically significant. Snow (1960) in *P. aristotelis*, Robertson (1971) and DesGranges (1982) in *P. auritus* and *P. pelagicus* and Schreiber (1976) in *Pelecanus occidentalis* observed also that growth rate or individual feeding frequency did not vary significantly as a function of the order of hatch. Berry (1976) in *P. capensis* noted an increase of the individual feeding frequency as a function of the order of hatch, and Cleary (1977), in *P. auritus*, and Nelson (1964), in *P. aristotelis*, observed significant differences between growth rates and weights of chicks of different hatching position within a brood. In fact, Cleary (1977) observed significant differences between asymptotes (not between growth rates) of members of a 3-chick brood, but was unable to determine whether

TABLE 5. Growth components of nestling Double-crested Cormorants.

KL*	KG**	Asymptote (g)	Mean weight of adult	R***	Regions	References
0.191	0.116	1889	1921	0.98	Iles de la Madeleine	This study
0.235	—	1650	2033	0.80	St. Lawrence estuary	Cleary (1977)
0.208	—	1900	2047	0.93	Maine	Dunn (1975b)
0.196	0.133	1900	1900	1.00	Maine	Ricklefs (1968, 1973)

*KL = K of the logistic equation

**KG = K of the Gompertz equation

***R = $\frac{\text{Asymptote}}{\text{adult weight}}$

the differences were due to the small sample size or to hatching sequence.

It was not feasible to measure the actual feeding rate of individual young Double-crested Cormorants at Ile aux Loups Marins during their first 20 days after hatching. However, meal sizes seemed equivalent for chicks 4 and 5 (after early death of chicks 1, 2 and 3) in the only 2-chick brood in which meal sizes were estimated, but these results do not allow firm conclusions to be made. Dunn (1975a) measured the food consumption of nestling Double-crested Cormorants under natural conditions but did not take into account the order of hatch. In cormorants, the survival rate is generally higher in the first-hatched than in the last-hatched chick (Van de Veen, 1973; Mitchell 1977; Urban, 1979). The last-hatched, in situations of food shortage, does not survive competition from older siblings which appropriate all food to the detriment of younger ones (Selective starvation: see O'Connor, 1978).

In summary, there was no evidence at the Ile aux Loups Marins cormorant colony in 1980 to indicate that chicks hatched last in a brood survive less well than those hatched earlier. In all cases, siblings showed comparable growth rates, mortality rates, and meal sizes and were fed at a similar individual frequency. The sample size of the 1980 study is too small for firm conclusions to be reached. All that can be said is that the data gathered indicate that cormorants breeding at Ile aux Loups Marins may adjust their chick feeding rates and meal sizes to brood size, and that siblings may be fed the same amount of food irrespective of their age and brood size. The feeding frequency of individual chicks seemed to decline with increasing brood size, but that may have been compensated for by an increase in meal size. That would explain, at least in part, why there is no apparent relationship between individual feeding frequency and growth rate, and chick position (order of hatching) in the brood.

Chick Growth Rates

Ricklefs (1968) concluded that the logistic equation best describes the weight growth of nidicolous birds; to that equation were assigned the growth curves of Double-crested Cormorants in the studies of Cleary (1977), Dunn (1975b) and Ricklefs (1968). However, growth curves for Great Cormorants (Ricklefs 1973) and Double-crested Cormorants (this study) are best fitted by the Gompertz equation. The inflection point and the maximum growth rate of curves fitted by that equation are reached more rapidly than in logistic curves, and the last part of the growth period is longer (Ricklefs 1968). Double-crested Cormorants of Ile de la Madeleine are tree-nesting, whereas those studied by Ricklefs (1968), Dunn (1975b) and Cleary (1977) were ground-nesting. Differences in the environmental conditions of both groups during the breeding season may explain the different forms of the growth curve.

If growth data for cormorants of Ile aux Loups Marins are analyzed using the logistic equation for the purpose of comparing the results with published data, the growth rate of those of Ile aux Loups Marins cormorants is a little slower than those obtained elsewhere (Table 5). The difference may be because our weights were taken later in the chick-rearing period when the growth rate is slower. The asymptote obtained was similar to those of Double-crested Cormorants breeding in Maine (Table 5). Weights of adult cormorants, except for those obtained in Maine by Ricklefs (1968, 1973), are higher than the growth asymptote of young. Snow (1960) and Potts (1968) reported that young Shags are fed by their parents for several weeks after the young abandon the nest. At Ile aux Loups Marins, Double-crested Cormorants regularly came back to the nest after fledging and were fed by their parents. This could be one of the reasons why they attain their adult weight only after leaving the nest.

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Literature Cited

- Berry, H. H. 1976. Physiological and behavioural ecology of the Cape Cormorant/ *Phalacrocorax auritus*. Madogua 9: 5-55.
- Cleary, L. 1977. Succès de reproduction du Cormoran à aigrettes, *Phalacrocorax auritus* a. sur 3 îles du St-Laurent, en 1975 et 1976. Thèse de maîtrise, Université Laval, Québec.
- Coulson, J. C., and J. M. Porter. 1985. Reproductive success of the Kittiwake *Rissa tridactyla*: the roles of clutch size, chick growth rates and parental quality. Ibis 127: 450-466.
- Coulter, M. C. 1981. A source of variation in avian growth studies: Undigested food. Journal of Field Ornithology 52: 62.
- DesGranges, J.-L. 1982. Weight growth of young Double-crested Cormorants in the St. Lawrence estuary, Quebec. Colonial Waterbirds 5: 79-86.
- Dunn, E. H. 1975a. Caloric intake of nestling Double-crested Cormorants. Auk 92: 553-565.
- Dunn, E. H. 1975b. Growth, body components and energy content of nestling Double-crested Cormorants. Condor 77: 431-438.
- Léger, C. 1984. Les Cormorans à aigrettes (*Phalacrocorax auritus*) des îles de la Madeleine, Québec: croissance, alimentation des jeunes et caractéristiques de nidification. Mémoire de maîtrise, Université de Montréal.
- Léger, C., and J. Burton. 1979. Alimentation estivale des Cormorans à aigrettes en relation avec la pêche aux harengs aux îles de la Madeleine. Rapport présenté à Pêche et Mer, Environnement Canada, par le Centre de recherches écologiques de Montréal.
- Léger, C., and R. McNeil. 1985. Nest attendance and care of young in Double-crested Cormorants. Colonial Waterbirds 8: 96-103.
- Mendall, H. L. 1936. The home-life and economic status of the Double-crested Cormorant *Phalacrocorax auritus* auritus (Lesson). University of Maine Studies, Maine Bulletin 39: 1-159.
- Mineau, P., G. E. J. Smith, R. Markel, and C.-S. Lam. 1982. Aging Herring Gulls from hatching to fledging. Journal of Field Ornithology 53: 394-402.
- Mitchell, R. M. 1977. Breeding biology of the Double-crested Cormorant on Utah Lake. Great Basin Naturalist 37: 1-23.
- Nelson, J. B. 1964. Factors influencing clutch-size and chick growth in the North Atlantic Gannet *Sula bassana*. Ibis 106: 63-77.
- Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. SPSS statistical package for the social sciences. McGraw-Hill, New York.
- O'Connor, R. J. 1978. Growth strategies in nestling passerines. Living Bird 16: 209-238.
- Palmer, R. S. (Editor). 1962. Handbook of North American birds, Volume 1. Yale University Press, New Haven.
- Pearson, T. H. 1968. The feeding biology of sea-bird species breeding on the Farne Islands, Northumberland. Journal of Animal Ecology 37: 521-552.
- Potts, G. R. 1968. Influence of eruptive movements, age, population size and other factors on the survival of the shag. Journal of Animal Ecology 37: 53-102.
- Ricklefs, R. E. 1967. A graphical method of fitting equations to growth curves. Ecology 48: 978-983.
- Ricklefs, R. E. 1968. Patterns of growth in birds. Ibis 110: 419-451.
- Ricklefs, R. E. 1973. Patterns of growth in birds II: Growth rate and mode of development. Ibis 115: 177-201.
- Robertson, I. 1971. The influence of brood-size on reproductive success in 2 species of cormorant, *Phalacrocorax auritus* and *P. pelagicus*, and its relation to the problem of clutch-size. M.Sc. thesis, University of British Columbia, Vancouver.
- Robinson, B. 1977. SPSS subprogram nonlinear-nonlinear regression. Manual no. 433. Northwestern University, Evanston, Illinois.
- Schreiber, R. W. 1976. Growth and development of nestling Brown Pelicans. Bird-Banding 47: 19-39.
- Siegel, S. 1956. Non parametric statistics for the behavioral sciences. McGraw-Hill, New York.
- Snow, B. K. 1960. The breeding biology of the shag, *Phalacrocorax aristotellus* on the Island of Lundy, Bristol Channel. Ibis 102: 554-575.
- Snow, B. K. 1963. Behaviour of the shag nestling (Part 2). British Birds 56: 164-186.
- Sokal, R. R., and F. S. Rohlf. 1981. Biometry. W. H. Freeman and Co., San Francisco.
- Urban, E. K. 1979. Observations on the nesting of the Great Cormorant in Ethiopia. Wilson Bulletin 91: 461-463.
- Van de Veen, H. E. 1973. Some aspects of the breeding demography of the Double-crested Cormorant (*Phalacrocorax auritus*) of Mandarte Island. Ph.D. thesis, Zoologisch Laboratorium der Rijksuniversiteit te Groningen, Groningen.

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Small Mammal Communities in Three Aspen Stand-age Classes

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Probst, John R., and Donald S. Rakstad. 1987. Small mammal communities in three aspen stand-age classes. *Canadian Field-Naturalist* 101(3): 362-368.

Small mammals were trapped in 25 aspen (*Populus* spp.) plots in northern Minnesota and in the Upper Peninsula of Michigan from 1977 to 1982. The plots were grouped into three age categories: recent clear-cuts (1-3 years), sapling plots (4-12 years), and mature plots (45-75 years). A total of 2502 individual mammals from eight genera and ten species were caught during 15 190 trap-station nights. Herbivores, primarily Southern Red-backed Voles, *Clethrionomys gapperi*, were most abundant in sapling stands, moderately abundant in mature stands, and least numerous in clear-cut stands. Omnivores (*Peromyscus* spp.) were least abundant in the sapling stands and most abundant in mature stands. The relative numerical dominance of the Deer Mouse, *P. maniculatus*, was greatest in clear-cut stands. Mature stands had the highest overall populations; clear-cuts and sapling stands had similar total populations on the average. Overall, our data suggest that harvesting trees temporarily reduces the total number of small mammals for several years. Small mammal populations varied greatly within and among the three stand-age categories, so it is difficult to predict populations of dominant species in individual stands. However, general trends in relative population levels of common species could be predicted by stand age-class alone; this variable was not a good predictor for the occurrence of less common species.

Key Words: Small mammal relative populations, annual variation of populations, species composition, clear-cutting, monitoring populations, *Populus* spp., *Clethrionomys gapperi*, *Peromyscus* spp.

Small mammals can be economically important in forest ecosystems as beneficial agents and/or as pests. Rodents can retard tree regeneration by consuming seeds (Sims and Buckner 1973; Hooven 1975) or by girdling seedlings (Radvanyi 1980). They also can have a positive influence by controlling forest insect pests (Buckner 1966) and pathogens (Powell 1982), and by dispersing seeds and spores (Maser et al. 1978). Recent United States, and in some cases State legislation has directed that a diversity of wildlife be maintained on public lands. Thus, land managers must be able to predict changes in the vertebrate fauna that result from management activities such as tree harvesting (Salwasser and Tappeiner 1981). In addition, faunal composition and species populations often must be monitored periodically to detect changes resulting from development or management. Reliable monitoring requires information about annual variation in populations for consistent conclusions and predictions (Raphael and Rosenberg 1983).

Few small mammal studies have investigated population changes associated with the management of broadleaf forests. Most previous studies of small mammals in forest habitats in Eastern North America have measured the effects of fire on these animals (e.g. Tester 1965; Ahlgren 1966; Sims and Buckner 1973; Fala 1975; Buech et al. 1977). Comparisons of the total abundance of small mammals between recently cut and mature forests are inconclusive or contradictory (Lovejoy 1975; Krull 1970; Kirkland 1977; Buech

et al. 1977). Kirkland also noted that change in the trophic composition was more pronounced among deciduous seral stages than among coniferous stages.

We studied small mammal populations in 25 aspen stands (*Populus tremuloides*, *P. grandidentata*, and *P. balsamifera*) of various ages. Through removal trapping we compared population levels using a capture rate index to determine whether stand age alone could be used by land managers to predict the relative abundance of small mammals.

Methods

Study Plots

From 1977 to 1982 we studied 25 aspen plots (Table 1) located in the Chippewa National Forest in north central Minnesota (47° 20'-47° 35'N, 93° 25'-94° 35'W), Ottawa National Forest in the Upper Peninsula of Michigan (46° 40'N, 89° 10'W), and the Cloquet Experimental Forest of the University of Minnesota near Cloquet, Minnesota (46° 41'N, 92° 31'W). Plots were grouped into three age categories: recent clear-cuts (1 to 3 years), saplings (4 to 12 years), and mature forest (45 to 75 years). No plots were sampled in the 13 to 45 year range. Stand size ranged from 4.0 to 16.0 hectares (Table 1).

We sampled small mammal populations for nine stand-years (i.e. some stands were sampled for more than one year) in five clear-cut stands one to three growing seasons after tree harvest. Aspen heights ranged from 0.6 to 3.7 m and averaged 1.2 m.

TABLE 1. Location, stand size, and stand-age of study plots.

Plot Name	Stand Age (years)	Stand Size (ha)	Year Sampled	Location
Pike Bay	M ^a	16.0	1977-79	Chippewa NF, MN
S-6 Experimental Watershed	M	7.0	1977	Chippewa NF
	1 North	4.0	1981	"
	1 South	4.0	1981	"
Murphy Lake	4	10.0	1977	"
	6,8	9.0	1979, 1981	"
Jessie Lake	8,12	10.5	1978, 1982	Chippewa NF
Bowstring Lake	9	6.4	1979	Chippewa NF
Cloquet	M	16.0	1977	Cloquet Forestry Center, MN
	2,3	9.0	1980-81	"
Ottawa #1	M	13.5	1977	Ottawa NF, MI
	M	11.0	1978	"
	M	9.0	1979	"
	1,2	8.0	1980-81	"
Ottawa #2	2	10.6	1978	"
	3-5	8.3	1979-81	"

^aM = mature ≥ 45 years.

There were eight stand-years in four aspen stands in the 4-12 year category. Stem heights ranged from 1.8 to 9.0 m. The Ottawa No. 2 stand was first trapped 2 years after cutting. The ground vegetation remained similar during the 4 years of study, but aspen growth averaged about 0.6 m each year. The Murphy Lake 7-year plot was adjacent to the 4- and 6-year plot; aspen heights increased from 2.4 to 4.1 meters. The average height of aspen stems in Jessie Lake for the 8-year old plot was only 1.9 m, but increased to 6.2 m at 12 years, with a large decrease in stem density.

We sampled small mammal populations for eight stand-years in four stands in the mature category. All mature stands except Pike Bay were subsequently harvested, and sampled for small mammals in the clear-cut stage.

Trapping Procedures

Trap stations were spaced at 15 m intervals along transect lines located 50 m apart. This grid resulted in 12 stations per hectare. Two McGill snap-traps baited with peanut butter were placed at each station and were checked and rebaited for five consecutive days. We recorded the date, station number, species, sex, and weight of each individual captured. Trapping was conducted in late September and October, allowing most species to complete reproduction for the year (R. R. Buech, personal communication).

Data Treatment

Capture-rate index data for comparing relative populations were in the form of counts standardized

to number per 1000 trap-station nights. The average capture rate indices were compared between the three stand categories for each species and for all species combined.

Several characteristics of the data required compensation for non-uniform conditions. First, the plot sizes were not uniform. However, the number of trap stations per hectare was constant at 12. Each plot capture rate was therefore weighted by its size in hectares. Second, the plot rates tended to be skewed toward the smaller counts, suggesting a departure from normality. The square root transformation was used to adjust for departures from normality. The one sample Kolmogorov-Smirnov test (Lindgren 1968: 329) was used on the transformed, weighted data to check for normality. This test resulted in non-significance at the $P = 0.20$ level for all rates and categories. Finally, the rate variances among plots were not homogeneous across categories. An adjustment to degrees of freedom was made in compensation for the non-homogeneity of variance (Snedecor and Cochran 1967: 115). Because there were only three categories for each rate, the transformed, weighted means were compared with simultaneous t-tests. The significance level was appropriately adjusted.

The preceding analysis weights averages by variation among stands, by stand size, and by number of years sampled. We also compared transformed, unweighted means by making no adjustments for stand size differences and by averaging captures rates

TABLE 2. Coefficients of variation (s/\bar{X}) of unweighted capture rates for annual variation and for stand variation.

Plot	Annual Variation ^a				Stand Variation ^b			
	Total	<i>Peromyscus maniculatus</i>	<i>Peromyscus leucopus</i>	<i>Clethrionomys gapperi</i>	Total	<i>Peromyscus maniculatus</i>	<i>Peromyscus leucopus</i>	<i>Clethrionomys gapperi</i>
Clearcut	0.33	0.41	0.58	0.22	0.22	0.54	1.94	0.84
Sapling	0.32	0.72	0.76	0.56	0.66	0.67	0.70	0.80
Mature	0.59	0.51	0.45	1.11	0.55	1.07	0.84	0.70
Overall average	0.39	0.55	0.61	0.57	0.50	0.80	0.84	0.75

^aAll stands sampled for more than one year.^bAnnual samples average for each stand.

of stands sampled for more than 1 year. Thus the unweighted means counted each stand equally within an age class. Means were significantly different ($P < 0.10$) for both weighted and unweighted analyses unless noted otherwise. In general, most weighted means were significantly different at higher levels because sample sizes were larger when annual samples were treated independently. Population variation among stands was compared to variation among years with the coefficient of variation ($CV = s/\bar{x}$).

Results

Annual Variation versus Stand Variation

Our data indicate considerable variation among stands and among years (Table 2) as well as among stand age categories. A comparison of coefficients of variations ($CV = s/\bar{X}$) for yearly samples of single stands versus CVs for stands in an age class (annual population index averaged) shows lower CVs for annual variation than stand variation. This suggests that the yearly samples used in the weighted analysis may not have been fully independent from each other. Thus, the unweighted capture rates were used in the following interpretation.

The distinction between annual variation and stand variation becomes diffuse in younger, fast-growing clear-cuts and sapling stands where habitats can change rapidly within a period of a few years. It is preferable to reach conclusions about animal populations in stand age classes based on replicate study plots and study years lumped together. We obtained eight replicate plots or years for each of the three stand-age classes. Three replicate samples are probably minimal for estimating small mammal populations (Steele et al. 1984). Despite large variability within stand age classes, the population trends for dominant species were almost always significant for comparisons among stand age classes.

Total Abundance and Diversity

During 15 190 Station-nights of trapping, 2502 mammals from ten species and eight genera were caught. In each of the three stand-age classes, only two

species were captured in more than three-fourths of the stand or annual replicates, and only four species were captured in more than half of the stand or annual replicates (Table 3). The weighted average capture rates (Table 3) and unweighted average capture rates (Table 4) showed the same patterns when differences between stand age classes were compared, so the unweighted rates are discussed below, unless stated otherwise. Clear-cut and sapling stands were similar for overall small mammal abundance. However, the average total population of mature stands was significantly greater ($P < 0.10$) than the average population in either clear-cut or sapling stands (Figure 1). Of three clear-cuts sampled before tree harvest as mature stands, two (S-6 and Cloquet) had reduced populations after harvest. The small mammal populations of the third (Ottawa #1) after cutting were similar to the 3-year average population before tree harvest. (Populations of small mammals were lower in all the Ottawa plots, so other factors such as geographic range or site may be important in the population differences.)

The average number of genera (Figure 1) was similar among the three stand-age classes. The total number of genera/species per age class is as follows: clear-cuts, 7/8; sapling, 7/9; mature 5/6. Overall, these data suggest that the sapling stands could have more species on the average (Table 3), because some shrews and voles are more likely to be in these stands.

Single Species

The dominant species captured were Southern Red-backed Vole, *Clethrionomys gapperi*, the Deer Mouse, *Peromyscus maniculatus*, and the White-footed Mouse, *P. leucopus*. Southern Red-backed Voles were least abundant in clear-cuts, but more abundant in the older stands (Figure 2). The clear-cut average population (Tables 3 and 4) was significantly less ($P < 0.10$) than the sapling or mature population. There was no significant difference between the mature and sapling population index. The Southern Red-backed Vole accounted for 21% of the total captures in clear-cuts, 76% in the sapling, and 38% in

TABLE 3. Frequency of occurrence and weighted capture-rate population index of small mammals (No. per 1000 Station-nights).

	Clearcut (n=9)		Sapling (n=8)		Mature (n=8)	
	Frequency (%)	Population Index	Frequency (%)	Population Index	Frequency (%)	Population Index
<i>Peromyscus maniculatus</i>	100	55.8 A ^a	88	10.1 B	100	108.1 C
<i>Peromyscus leucopus</i>	11	0.3 A	11	1.1 B	63	62.4 C
<i>Clethrionomys gapperi</i>	78	20.9 A	75	86.2 B	88	69.9 B
<i>Microtus pennsylvanicus</i>	56	4.9	63	1.5	0	0.0
<i>Sorex cinereus</i>	67	3.4	88	7.1	38	3.5
<i>Sorex arcticus</i>	0	0.0	38	1.7	0	0.0
<i>Blarina brevicauda</i>	22	3.8	38	1.6	63	6.5
<i>Zapus hudsonius</i>	22	0.4	0	0.0	0	0.0
<i>Eutamias minimus</i>	11	0.2	25	1.6	0	0.0
<i>Tamias striatus</i>	0	0.0	25	0.5	12	0.5
TOTAL		89.7 A		111.4 A		250.9 B

^aSignificant differences between means across a row are followed by different capital letters.

mature stands (Figure 2). The Meadow Vole, *Microtus pennsylvanicus*, was trapped in small numbers in wet, grassy patches in some clear-cut and sapling stands, but was absent in mature stands.

The Deer Mouse and the White-footed Mouse constituted 68% of the total captures in clear-cuts, 11% in sapling, and 56% in mature stands (Figure 2). The population patterns of the two *Peromyscus* species were somewhat different (Figure 2). Both species were most abundant in mature stands, but the White-footed Mouse was present in only one clear-cut stand. The White-footed Mouse was much less abundant in clear-cuts relative to mature stands, and slightly more numerous in sapling stands than clear-cuts. The populations of White-footed Mice were significantly different from each other for all three age categories. Deer Mice maintained stable populations in clear-cuts relative to mature stands. The difference between Deer Mouse populations in sapling versus clear-cut stands was significant ($P < 0.05$), as was the difference between sapling and mature stands ($P < 0.10$). For two of three clear-cut stands which were sampled before cutting, the populations of Deer

Mice increased by a factor of 2X following harvest of the mature stand; the population of the third (Ottawa #1) was relatively stable. One stand (Ottawa #2) was sampled in the clear-cut and sapling categories for two years each. This stand had lower populations of Deer Mice as a sapling stand than as a clearcut stand (Table 3). Both *Peromyscus* species were significantly less abundant in sapling stands relative to mature ones.

Relatively few shrews were trapped, perhaps because snap traps are not efficient in capturing shrews (Raphael and Rosenberg 1983; Williams and Braun 1983). Still, general trends can be recognized for the Short-tailed Shrew, *Blarina brevicauda*, which was most abundant in mature forests (Table 3). The Masked Shrew, *Sorex cinereus*, was more abundant in the young, sapling plots than in either clear-cut or mature stands. Other species were trapped, but were not common enough to analyze stand-age trends. The Arctic Shrew, *S. arcticus*, was only captured in one stand into which it had presumably dispersed from an adjacent bog. The Eastern Chipmunk, *Tamias striatus*, and Least Chipmunk, *Eutamias minimus*, were captured but may not have been sampled reliably

TABLE 4. Unweighted capture-rate population index^a.

Plot	Total Capture Rate	No. of Species	<i>Peromyscus</i> spp. combined	<i>Peromyscus</i> <i>maniculatus</i>	<i>Peromyscus</i> <i>leucopus</i>	<i>Clethrionomys</i> <i>gapperi</i>
CLEAR-CUTS						
Ottawa #1 (2) ^b	86.5	3-4	63.0	63.0	0.0	14.0
S-6 (1)	118.5	2-3	89.5	89.5	0.0	25.0
Cloquet (3)	69.7	2-5	22.3	21.7	0.7	38.3
Ottawa #2 (2)	102.5	3-6	80.0	80.0	0.0	0.0
Mean (\bar{x})	94.3 A ^c	3.7	63.7	63.5 A	0.2 A	19.3 A
SAPLING						
Ottawa #2 (2)	27.5	4	15.5	15.5	0.0	4.5
Murphy (3)	173.7	5-7	5.0	3.7	1.3	14.7
Jessie (2)	102.5	3-5	18.0	16.5	1.5	81.0
Bowstring (1)	70.0	5	4.0	2.0	2.0	58.0
Mean (\bar{x})	93.4 A	4.9	10.6	9.4 B	1.2 B	71.3 B
MATURE						
Pike Bay (3)	387.7	3-4	298.7	194.7	104.0	88.7
Ottawa #1 (3)	75.0	2-4	55.0	55.0	0.0	3.3
S-6 (1)	208.0	5	76.0	40.0	36.0	120.0
Cloquet (1)	267.0	6	93.0	13.0	80.0	147.0
Mean (\bar{x})	234.4 A	3.8	130.7	75.7 C	55.0 C	89.7 B

^aNumber per 1000 trap-station nights.^bNumber of years studied.^cSignificant differences between means in a column are indicated by different letters.

with the small traps that we used. The Meadow Jumping Mouse, *Zapus hudsonius* was trapped in only two years in a clear-cut plot with extensive grassy areas in the Ottawa National Forest.

Discussion

Population and Stand-Age

The population index data in this study showed a decrease of small mammals after clear-cutting and a subsequent increase in small mammals in the sapling age class. Although there was much overlap in total small mammal abundance among age classes, abundance was generally lowest in clear-cut plots, slightly higher in sapling stands, and highest in mature plots. In contrast, Kirkland (1977) reported significant increases in the density of small mammals following clear-cutting in northern Appalachian forests while Krull (1970) found little difference after clear-cutting in northern hardwood forests in New York. Small mammal density in coniferous forests after clear-cutting also varies from study to study (Hooven and Black 1976; Martell and Radvanyi 1977; West et al. 1980). Apparently some conifer forests may have lower small mammal populations than hardwood forests in the same region (Beer et al. 1973; Kirkland 1977; Hill 1982).

Community Composition

Although the total abundance of small mammals can be similar among stand-age classes, populations of individual species may differ substantially. We found the change in species composition among the three age classes to be more prominent than differences in capture rates. Martell and Radvanyi (1977) also noted this pattern. In our study, captures for Southern Red-backed Voles ranged from 21 to 76% of the total capture within each stand-age class and from 11 to 68% for *Peromyscus* spp.

The above change in composition can be described as shifts in trophic groups. Herbivores (predominantly Southern Red-backed Voles) as a group decreased after harvest in our study, although the Meadow Vole was found only in stands under 6 years of age. However, Kirkland (1977) reported an increase in Southern Red-backed Voles after harvest. Lovejoy (1975) also reported an increase in Southern Red-backed Vole numbers in areas that were originally dry sites. Other studies had findings similar to ours: voles decreased after harvest or fire (Ahlgren 1966; Krefling and Ahlgren 1974; Buech et al. 1977; West et al. 1980; Halvorson 1982).

Omnivores decreased in clear-cuts and still more in the sapling stands in our study. Lovejoy (1975)

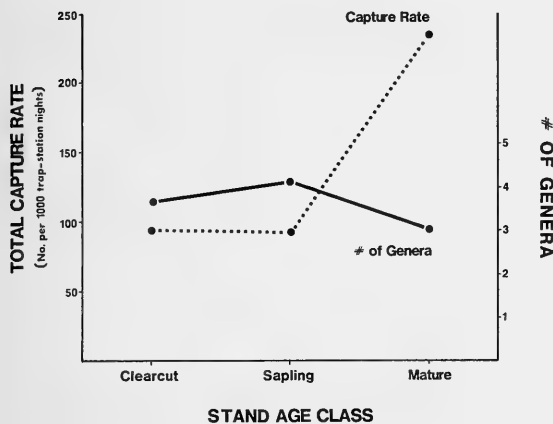


FIGURE 1. Number of genera and relative abundance (unweighted capture rate number per 1000 trap station nights) of all species in each stand-age category.

reported a similar though less pronounced trend for the Deer Mouse. In Kirkland's (1977) study, omnivore populations remained stable after clear-cutting with no decline until stands reached 6 to 15 years in age. Other studies have shown an increase in *Peromyscus* after habitat disturbance by fire (Ahlgren 1966; Krefting and Ahlgren 1974; Buech et al. 1977; Halvorson 1982).

Insectivores (Soricidae) showed a slight decrease after clearcutting in our study, but too few animals were trapped to show conclusive trends. Kirkland (1977) and Lovejoy (1975) also found that populations of *Soricidae* changed less than those of herbivores or omnivores following tree harvest. The Short-tailed Shrew was only half as abundant after harvest while the Masked Shrew, maintained stable populations in Kirkland's study. In our study the Short-tailed Shrew also was more abundant in mature relative to clear-cut forests. Most Masked Shrews were trapped in the young regenerating stands, but differences were not significant.

Predicting Small Mammal Communities by Stand-Age

We conclude that it is possible to describe average, overall trends in relative population levels of dominant species by stand-age class alone, without supplementary habitat measurements. Our ability to predict the occurrence of less common species, or absolute populations of dominant mammals in single stands, is poor, however. Far too many ecological studies — including many small mammal studies — base their conclusions on single-sample surveys of

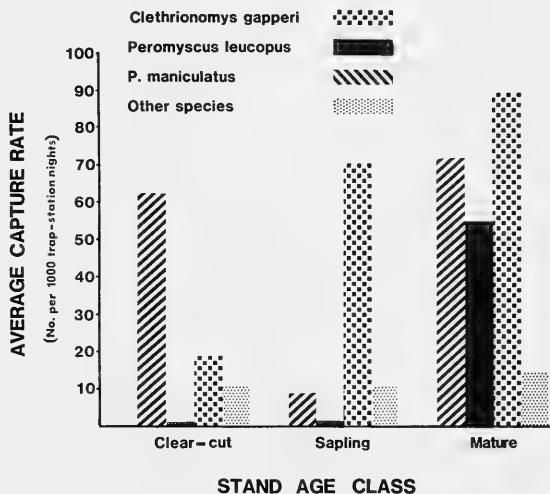


FIGURE 2. Relative population of small mammal species in each stand age class.

communities without consideration of variation among plots or years (Wiens 1981). In this study with multiple stands in each age class and limited multi-year sampling, there is substantial variation among stands. These results agree with others (Raphael and Rosenberg 1983) that suggest caution when sampling wildlife for habitat monitoring or impact assessment, especially when such sampling encompasses stands which are more heterogeneous within a stand than the ones in our study, which were selected for their relative uniformity.

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Literature Cited

- Ahlgren, C.E. 1966. Small mammals and reforestation following prescribed burning. *Journal of Forestry* 64: 614-618.
- Beer, J. R., R. B. Brander, and C. T. Cushwa. 1973. Small mammal populations. Pp. 27-30 in *Wilderness Ecology: The upland plant communities, woody browse production, and small mammals of two adjacent 33-year-old wildfire areas of northeastern Minnesota*. United States Department of Agriculture, Forest Service, GTR NC-7,

- North Central Forest Experiment Station, St. Paul, Minnesota.
- Buckner, C. H.** 1966. The role of vertebrate predators in the biological control of forest insects. *Annual Review of Entomology* 11: 449-470.
- Buech, R. R., K. Siderits, R. E. Radtke, H. L. Sheldon, and D. Elsing.** 1977. Small mammal populations after a wildfire in northeastern Minnesota. United States Department of Agriculture, Forest Service Research Paper NC-151. North Central Forest Experiment Station, St. Paul, Minnesota. 8 pp.
- Fala, R. A.** 1975. Effects of prescribed burning on small mammal populations in a mixed-oak clearcut. *Journal of Forestry* 72: 586-587.
- Halvorson, C. H.** 1982. Rodent occurrence, habitat disturbance, and seed fall in a larch-fir forest. *Ecology* 63: 423-433.
- Hill, B. J.** 1982. Small mammal habitat associations in selected timber and community types on the White Mountain National Forest, New Hampshire. M.Sc. thesis, University of Massachusetts, Amherst, Massachusetts. 140 pp.
- Hooven, E. F.** 1975. Baiting to reduce losses of conifer seeds to small forest mammals. Oregon State University, Forestry Research Laboratory, Corvallis, Oregon. Research Note 55. 3 pp.
- Hooven, E. F., and H. C. Black.** 1976. Effects of some clearcutting practices on small-mammal populations in western Oregon. *Northwest Science* 50: 189-208.
- Kalin, O. T.** 1976. Distribution, relative abundance, and species richness of small mammals in Minnesota, with an analysis of some structural characteristics of habitats as factors influencing species richness. Ph.D. thesis, University of Minnesota, St. Paul, Minnesota. 160 pp.
- Kirkland, G. L.** 1977. Responses of small mammals to the clearcutting of northern Appalachian forests. *Journal of Mammalogy* 58: 600-609.
- Krefting, L. W., and C. E. Ahlgren.** 1974. Small mammals and vegetation changes after fire in a mixed conifer-hardwood forest. *Ecology* 55: 1391-1398.
- Krull, J. N.** 1970. Small mammal populations in cut and uncut northern hardwood forests. *New York Fish and Game Journal* 17: 128-130.
- Lindgren, B. W.** 1968. *Statistical Theory*, Second edition. Macmillan, New York. 521 pp.
- Lovejoy, D. A.** 1975. The effect of logging on small mammal populations in New England northern hardwoods. University of Connecticut Occasional Papers 2: 269-291.
- Martell, A. M., and A. Radvanyi.** 1977. Changes in small mammal populations after clear-cutting of northern Ontario black spruce forest. *Canadian Field-Naturalist* 91: 41-46.
- Maser, C., J. M. Trappe, and D. C. Ure.** 1978. Implications of small mammal mycophagy to the management of western coniferous forests. *Transactions of the North American Wildlife and Natural Resources Conference* 43: 78-88.
- Powell, J. M.** 1982. Rodent and lagomorph damage to pine stem rusts, with special mention of studies in Alberta. *Canadian Field-Naturalist* 96: 287-294.
- Radvanyi, A. M.** 1980. Control of small mammal damage in the Alberta oil sands reclamation and afforestation program. *Forest Science* 26: 687-702.
- Raphael, M. G., and K. V. Rosenberg.** 1983. An integrated approach to wildlife inventories in forest habitats. Pp. 219-222 in *Proceedings of an international conference on renewable resource inventories for monitoring changes and trends*, Corvallis, Oregon, August 15-19, 1983. *Edited by John F. Bell and Toby Atterbury*. Oregon State University, College of Forestry, Corvallis, Oregon. 737 pp.
- Salwasser, H., and J. C. Tappeiner II.** 1981. An ecosystem approach to integrated timber and wildlife habitat management. *Transactions of North American Wildlife and Natural Resources Conference* 46: 473-487.
- Sims, H. P., and C. H. Buckner.** 1973. The effects of clearcutting and burning of *Pinus banksiana* forests on the populations of small mammals in southeastern Manitoba. *American Midland Naturalist* 90: 228-231.
- Snedecor, G. W., and W. G. Cochran.** 1967. *Statistical Methods*, sixth edition. Iowa State University Press, Ames, Iowa. 523 pp.
- Steele, B. B., R. L. Bayn Jr., and C. V. Grant.** 1984. Environmental monitoring using populations of birds and small mammals: analysis of sampling effort. *Biological Conservation* 30: 157-172.
- Tester, J. R.** 1965. Effects of a controlled burn on small mammals in a Minnesota oak-savanna. *American Midland Naturalist* 74: 240-243.
- Tevis, L. Jr.** 1956. Effect of a slash burn on forest mice. *Journal of Wildlife Management* 20: 405-409.
- West, S. D., R. G. Ford, and J. C. Zasada.** 1980. Population response of the northern red-backed vole (*Clethrionomys rutilus*) to differentially cut white spruce forest. United States Department of Agriculture, Forest Service, PNW-362, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. 15 pp.
- Wiens, J. A.** 1981. Single-sample surveys of communities: are the revealed patterns real? *American Naturalist* 117: 90-98.
- Williams, D. F., and S. E. Braun.** 1983. Comparison of pitfall and conventional traps for sampling small mammal populations. *Journal of Wildlife Management* 47: 841-845.

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Eggshell Quality and Organochlorine Residues in Eggs of Merlins, *Falco columbarius*, in Southeastern Montana

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Becker, Dale M., and Carolyn Hull Sieg. 1987. Eggshell quality and organochlorine residues in eggs of Merlins, *Falco columbarius*, in southeastern Montana. *Canadian Field-Naturalist* 101(3): 369-372.

Eggshell weight and thickness indices of Richardson's Merlin (*Falco columbarius richardsonii*) eggs collected in southeastern Montana were significantly ($p \leq 0.01$) lower than pre-1946 samples. Montana eggshells showed reductions of 13% in shell weight and 20% in shell thickness indices when compared to eggshells collected before 1946. The decreased eggshell weights and thickness indices and the occurrence of 7 organochlorine compounds in Merlin eggs recently collected in southeastern Montana indicates that this raptor population merits periodic monitoring.

Key Words: Organochlorines, Merlin, *Falco columbarius*, pesticides, Montana.

Reductions in eggshell weights and thickness indices of numerous raptors have been associated with accumulations of organochlorine residues, particularly DDE, in breeding adults (Newton 1979). Decreases in eggshell thickness accompanied by population declines have been reported for Bald Eagles (*Haliaeetus leucocephalus*), Ospreys (*Pandion haliaetus*), and Peregrine Falcons (*Falco peregrinus*) (Hickey and Anderson 1968).

Organochlorine pesticide contamination was first correlated with decreased eggshell weights and thickness indices and lower reproductive success of Merlins (*Falco columbarius*) in Great Britain (Ratcliffe 1970; Newton 1973; Newton et al. 1978, 1981). Detrimental effects of chlorinated hydrocarbons on Merlin reproductive success have also been detected in Canada (Fox 1971; Temple 1972; Fyfe et al. 1976; Hodson 1976; Fox and Donald 1980). In the United States, published information is limited to analyses of pesticide residues in three eggs that failed to hatch at a Montana nest (Ellis 1976).

This paper presents eggshell weights and thickness indices and organochlorine residue concentrations in eggs of Richardson's Merlins (*F. c. richardsonii*) collected in southeastern Montana. These mensural characteristics are compared with measurements of pre-pesticide era (pre-1946) Merlin eggshells from various locations in the northern Great Plains. Potential effects of reduced eggshell quality and pesticide contamination on reproduction of Merlins in this area are discussed.

Study Area

The study area encompassed 39 448 ha in southeastern Montana. Habitat used by breeding Merlins consisted of forested hills and sandstone buttes

ranging to approximately 300 m above the adjacent grasslands. Vegetative cover on the area was composed of approximately 27% forest cover and 67% Big Sagebrush (*Artemisia tridentata*)-grassland interspersed with barren buttes. The dominant tree species was Ponderosa Pine (*Pinus ponderosa*); primary grass species were Western Wheatgrass (*Agropyron smithii*), and Blue Grama (*Bouteloua gracilis*).

Methods

During 1978 through 1981, 18 intact Merlin eggs that failed to hatch were collected from 18 different clutches for analyses of eggshell weight and thickness. Contents of eggshells were removed through a hole ≤ 3 mm in diameter, and eggshells were washed and air-dried for at least 90 days. Merlin eggshells in museum collections were used as the control for comparison of eggshell quality. The museum eggs had been collected between 1865 and 1945 in the northern Great Plains of North America (Montana, North Dakota, Alberta, Saskatchewan); eggshells with holes > 3 mm in diameter were rejected. Eggshell dimensions were not significantly different among Merlin eggs collected throughout the northern Great Plains (Bent 1938; Brown and Amadon 1968; Fox 1971).

Length and breadth of eggshells collected during the study and the museum eggshells were measured to 0.01 mm, and each eggshell was weighed to the nearest 1 mg. Eggshell thickness indices were calculated by the formula $w/(l \times b)$; where w = weight (mg); l = length (mm), and b = breadth (mm) (Ratcliffe 1967). Differences between mean eggshell weights and thickness indices of the Montana sample and the pre-

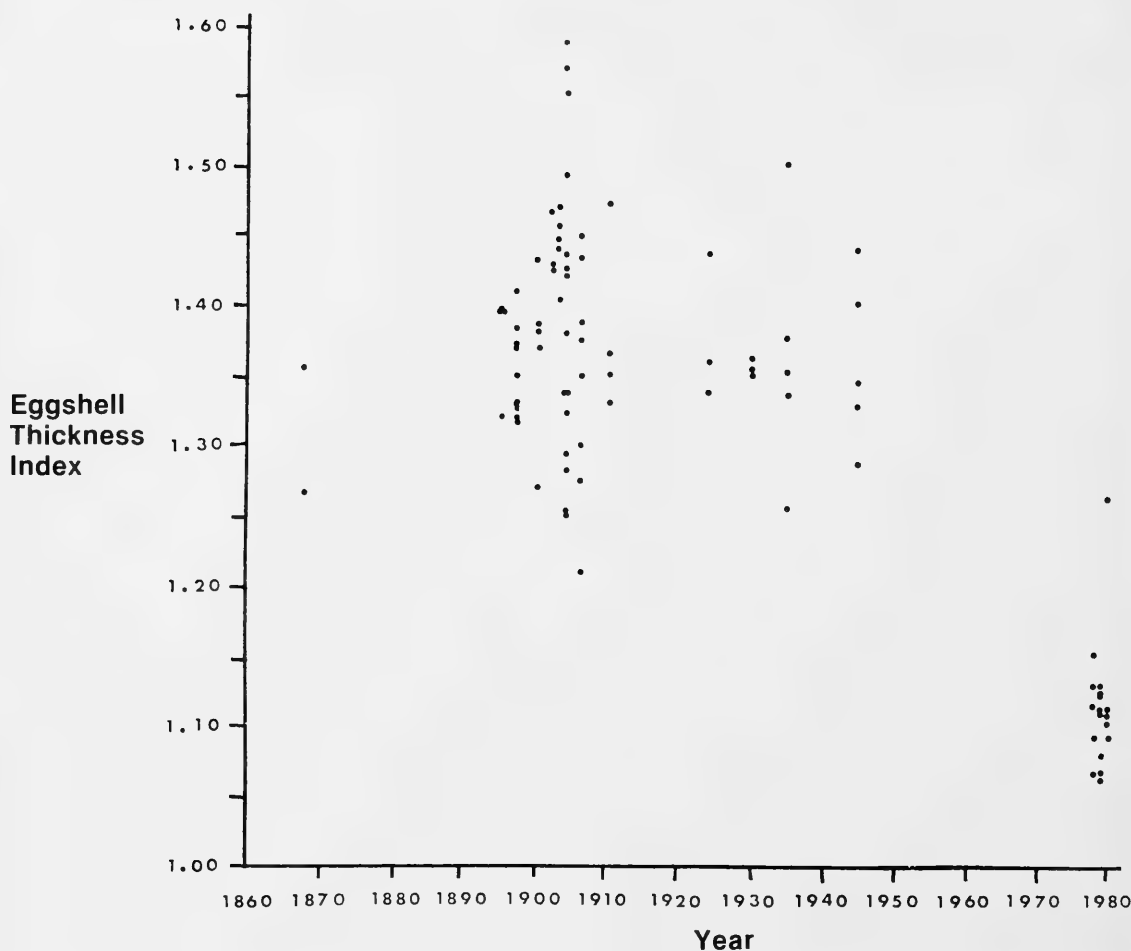


FIGURE 1. Changes in Richardson's Merlin eggshell thickness indices. Pre-1946 indices are from museum specimens collected in the northern Great Plains. More recent indices (1978-1981) were calculated from eggs collected in southeastern Montana.

1946 sample were compared with heterogeneous variance t-tests (Steel and Torrie 1980), and results were considered significant at $\alpha \leq 0.05$.

Four Merlin eggs were collected from four different clutches to be analyzed for concentrations of organochlorines. The eggs were wrapped in aluminum foil, frozen, and shipped to Patuxent Wildlife Research Center for analyses. Contents were removed from eggshells and analyzed for DDE, DDD, DDT, dieldrin, heptachlor epoxide, oxychlordane, cis-chlordane, trans-chlordane, cis-nonachlor, endrin, toxaphene, and polychlorinated biphenyls (PCB). Analytical methodology followed standard procedures described by Cromartie et al. (1975). Results are presented in ppm (corrected wet weight).

Results

Weights of the eighteen eggshells ranged from 1440 to 1570 mg ($\bar{x} = 1468$, S.D. = 34), compared to a range of 1326 to 1870 mg ($\bar{x} = 1677$, S.D. = 127) for 71 pre-1946 Merlin eggshells. Average weight of the Montana eggshells was 13% lower ($t = 15.0$, $P \leq 0.01$) than the average weight of the pre-pesticide eggshells. Eggshell thickness indices for the recent Merlin eggshells ranged from 1.02 to 1.21 ($\bar{x} = 1.07$, S.D. = 0.04). These indices were 20% lower ($t = 30.4$, $P \leq 0.01$) than the pre-1946 thickness indices, which ranged from 1.20 to 1.54 ($\bar{x} = 1.33$, S.D. = 0.07) (Figure 1).

DDE residues were detected in four eggs analyzed for organochlorine compounds ($\bar{x} = 6.7$, S.D. = 3.8); DDE residues in 3 eggs were above 6 ppm (7.2, 8.7, 9.6 ppm). Trace amounts of dieldrin ($\bar{x} = 0.1$, S.D. = 0.1),

heptachlor epoxide (\bar{x} = 0.2, S.D. = 0.2), oxychlordane (\bar{x} = 0.1, S.D. = 0.1), cis-chlordane (\bar{x} = 0.1, S.D. = 0.1), trans-chlordane (\bar{x} = 0.1, S.D. = 0.1), and PCB (\bar{x} = 0.3, S.D. = 0.4) were also detected in some samples. Organochlorine compounds not detected included DDD, DDT, cis-nonachlor, endrin, and toxaphene.

Discussion

The decrease in eggshell weight (13%) from pre-1946 levels is similar to declines in eggshell weights of Merlin eggs collected in Britain and in Canada. Mean weights in Britain declined 13% (from 1.6 g for eggshells collected from 1900–49, to 1.4 g for eggshells collected between 1951 and 1964) (Ratcliffe 1970). Merlin eggshells collected in Canada from 1950 to 1969 were 23% lower in weight when compared with a sample collected from 1930 to 1949 (Fox 1971).

Studies in Great Britain and North America have documented decreases in thickness indices of eggshells since the pre-pesticide era. Merlin eggshell thickness indices in one British study declined 13% compared with eggshells collected before pesticide use (Newton 1973). However, thickness indices decreased 21% and 22% in the Peak District and Northumberland, Great Britain, respectively (Newton et al. 1978, 1981). A 9% decrease in thickness indices in Merlin eggshells from eastern Canada was reported by Temple (1972). In Alberta, eggshell thickness indices decreased 10% from pre-pesticide levels for samples containing low concentrations of organochlorines and 25% for samples with high organochlorine contamination (Fox and Donald 1980). The 20% decrease in thickness indices of our sample of Montana Merlin eggs is within the upper range of results reported previously.

It is impossible to identify precisely the source of the seven organochlorines found in Merlin eggs in southeastern Montana. Dieldrin and DDT were used in Montana in the 1960s and early 1970s (G. McOmber, Montana Department of Agriculture, personal communication). Merlins that breed in Montana may also accumulate organochlorine residues by consuming contaminated prey along migratory routes or in wintering areas. Merlins banded in Alberta have been recovered as far south as Mexico and Costa Rica (U. Banasch, Canadian Wildlife Service, personal communication), and Henny et al. (1982) indicated that Peregrine Falcons are accumulating pesticides on wintering grounds in Latin America. Regardless of the source, the presence of organochlorines in Merlin eggs from southeastern Montana indicates that pesticide contamination may be contributing to a lowered eggshell weight and index of thickness in this area.

The DDE residues in the four eggs analyzed were lower than peak concentrations reported for other Merlin populations. DDE concentrations in Merlin eggs collected in Britain were as high as 19.8 ppm wet weight (Ratcliffe 1970), and concentration of DDE averaged 9.4 ppm wet weight in three eggs from the same clutch collected in central Montana (Ellis 1976). Concentrations in three eggs in the present study may be high enough to affect the reproductive success of this population (O. H. Pattee, U. S. Fish and Wildlife Service, personal communication).

Dieldrin has also been implicated as a possible cause of eggshell thinning (Ratcliffe 1970). Sub-lethal levels of dieldrin consumed by Prairie Falcons, *Falco mexicanus*, have been correlated with reductions in eggshell thickness indices (Enderson and Berger 1970). Greater toxicity has been reported for birds with dieldrin residues than birds with residues of DDT or its metabolites (Fyfe et al. 1969). Heptachlor and chlordane (including chlordane products) probably do not induce eggshell thinning, but have been reported to be toxic at higher levels of accumulation (Fyfe et al. 1969; Blus et al. 1983).

The significant decrease in eggshell quality and the presence of DDE residues above 6 ppm in 3 of 4 Merlin eggs from southeastern Montana are cause for concern. Reproductive success of this population ranged from 3.0 to 3.3 fledglings per active nest and averaged 3.7 fledglings per successful nest (Becker and Sieg 1985), results comparable to or somewhat higher than the results of similar studies in Canada (Fox 1964; Fox 1971; Hodson 1976; Oliphant and Thompson 1978; Fox and Donald 1980). It is possible that the added eggs collected in southeastern Montana may have presented a picture of poorer eggshell quality than was actually the case. Because it is not known whether eggshell quality and organochlorine residue levels are stable or still changing, further monitoring of these factors as well as reproductive success is recommended to enable managers to identify trends in Merlin reproductive performance.

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Literature Cited

- Becker, D. M., and C. Hull Sieg.** 1985. Breeding chronology and reproductive success of Richardson's Merlins in southeastern Montana. *Raptor Research* 19: 52-55.
- Bent, A. C.** 1938. Life histories of North American birds of prey, Part 2. United States National Museum Bulletin 170. 482 pp.
- Blus, L. J., O. H. Pattee, C. J. Henny, and R. M. Prouty.** 1983. First records of chlordane-related mortality in wild birds. *Journal of Wildlife Management* 47: 196-198.
- Brown, L., and D. Amadon.** 1968. Eagles, hawks, and falcons of the world. Volume 2. McGraw-Hill Book Co., New York. 945 pp.
- Cromartie, E., W. L. Reichel, L. N. Locke, A. A. Belisle, T. E. Kaiser, T. G. Lamont, B. M. Mulhern, R. M. Prouty, and D. M. Swineford.** 1975. Residues of organochlorine pesticides and polychlorinated biphenyls and autopsy data for Bald Eagles, 1971-72. *Pesticide Monitoring Journal* 9: 11-14.
- Ellis, D. H.** 1976. First breeding records of Merlins in Montana. *Condor* 78: 112-114.
- Enderson, J. H., and D. D. Berger.** 1970. Pesticides: eggshell thinning and lowered production of young in Prairie Falcons. *Bioscience* 20: 355-356.
- Fox, G. A.** 1964. Notes on the western race of the Pigeon Hawk. *Blue Jay* 22: 140-147.
- Fox, G. A.** 1971. Recent changes in the reproductive success of the Pigeon Hawk. *Journal of Wildlife Management* 35: 122-128.
- Fox, G. A., and T. Donald.** 1980. Organochlorine pollutants, nest-defense behavior, and reproductive success in Merlins. *Condor* 81: 81-84.
- Fyfe, R. W., J. Campbell, B. Hayson, and K. Hodson.** 1969. Regional population declines and organochlorine insecticides in Canadian Prairie Falcons. *Canadian Field-Naturalist* 83: 189-200.
- Fyfe, R. W., R. W. Risebrough, and W. Walker II.** 1976. Pollutant effects on the reproduction of the Prairie Falcons and Merlins of the Canadian prairies. *Canadian Field-Naturalist* 90: 346-355.
- Henny, C. J., F. P. Ward, K. E. Riddle, and R. M. Prouty.** 1982. Migratory Peregrine Falcons, *Falco peregrinus*, accumulate pesticides in Latin America during winter. *Canadian Field-Naturalist* 96: 333-338.
- Hickey, J. J., and D. W. Anderson.** 1968. Chlorinated hydrocarbons and eggshell changes in raptorial and fish-eating birds. *Science* 162: 271-273.
- Hodson, K. A.** 1976. The ecology of Richardson's Merlins on the Canadian prairies. M.Sc. thesis, University of British Columbia, Vancouver. 83 pp.
- Newton, I.** 1973. Egg breakage and breeding failure in British Merlins. *Bird Study* 20: 241-244.
- Newton, I.** 1979. Population ecology of raptors. Buteo Books, Vermillion, South Dakota. 399 pp.
- Newton, I., E. R. Meek, and B. Little.** 1978. Breeding ecology of the Merlin in Northumberland. *British Birds* 71: 376-398.
- Newton, I., J. E. Robson, and D. W. Yalden.** 1981. Decline of the Merlin in the Peak District. *Bird Study* 18: 225-234.
- Oliphant, L. W., and W. J. P. Thompson.** 1978. Recent breeding success of Richardson's Merlins in Saskatchewan. *Raptor Research* 12: 35-39.
- Ratcliffe, D. A.** 1967. Decrease in eggshell weight in certain birds of prey. *Nature* 215: 208-210.
- Ratcliffe, D. A.** 1970. Changes attributable to pesticides in egg breakage frequency and eggshell thickness in some British birds. *Journal of Applied Ecology* 7: 67-115.
- Steel, R. G., and J. H. Torrie.** 1980. Principles and procedures of statistics. Second edition. McGraw-Hill Book Co. 633 p.
- Temple, S. A.** 1972. Chlorinated hydrocarbon residues and reproductive success in eastern North American Merlins. *Condor* 74: 105-106.

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Population Dynamics of Moose, *Alces alces*, on the South-coast Barrens of Newfoundland

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Albright, Craig A., and Lloyd B. Keith. 1987. Population dynamics of Moose, *Alces alces*, on the south-coast barrens of Newfoundland. *Canadian Field-Naturalist* 101(3): 373–387.

We studied a Moose (*Alces alces*) population on the south-coast barrens of Newfoundland during 1982–84. Numbers had declined in this region from $> 1.9/\text{km}^2$ in 1960 to $0.8/\text{km}^2$ by 1973; an aerial census in February 1983 also gave an estimate of $0.8/\text{km}^2$. Bull-cow ratios averaged 27 : 73 in summer (prehunt) and 17 : 83 in spring (posthunt). Forty-seven percent of adult bulls and 13% of adult cows were yearlings. Annual adult survival, calculated from demographic and harvest data, was 47% for bulls and 86% for cows; annual survival of cows 2–9 years old, calculated from composite life-table analysis of age ratios was 84%. The mean annual kill of 19% by hunters accounted for 76–100% of adult losses. Survival of calves was estimated from demographic data at 69% annually; calves of six radio-collared cows all survived their first year. Low reproduction was suggested by a twinning rate of $< 1\%$, an absence of calves with cows < 4 years old, and infrequent consecutive-year calf production by older cows. Moose moved from open barrens to traditional wintering sites in woods as snow accumulated during the December–February period. Twenty-one radio-collared adults were within 10 km of their summer home-range centers on 92% of winter locations. Seventy-seven percent of these locations were in Balsam Fir, *Abies balsamea*, woods and associated mixed-conifer scrub. The woods provided mainly winter cover, the fir scrub provided food. Senescence of trees and heavy browsing of understory regeneration by Moose are tending to convert fir woods to fir scrub and sparse stands of Black Spruce, *Picea mariana*. The predictable consequences include major losses of winter range and increased seasonal movements of Moose. Low productivity of this Moose population likely reflects a combination of poor winter nutrition, severe winter weather (low temperatures and high winds), and highly unbalanced adult sex ratios. Maintenance of the population at current levels is dependent on unusually high calf survival in a largely predator-free environment.

Key Words: Moose, *Alces alces*, population dynamics, winter range, browse, Balsam Fir, *Abies balsamea*, Newfoundland.

Moose, *Alces alces*, were introduced to insular Newfoundland in 1878 and 1904 (Pimlott 1953). Populations on the south-coast barrens of southwestern Newfoundland irrupted during the 1960s, increasing to high densities with inadequate hunting pressure, then declining from malnutrition due to overbrowsing (Mercer and Manuel 1974). An area-quota system of Moose hunting was established in 1973 to regulate Moose populations on small management units commensurate with habitat and social demands (Mercer and Strapp 1978).

The aim of our study was to describe the population dynamics of Moose in Management Unit 11 (Dashwoods) and to assess winter range conditions. Unit 11 is the primary fly-in zone for guided nonresident Moose hunters in Newfoundland. In this paper we (1) summarize population demography, (2) model changes in numbers from a knowledge of time- and age-specific rates of birth and death, and (3) assess how such rates are affected by winter range conditions and hunting kill. Field studies were conducted from June 1982 to August 1984.

Study Area

The 2936-km² Dashwoods Moose Management Unit of southwestern Newfoundland (Figure 1) is approximately 42% open barrens and bog, 27% conifer forest, 21% conifer scrub, and 10% freshwater (J. A. Hancock, Newfoundland Wildlife Division, unpublished report). The southern two-thirds is subalpine heathland (barrens) with scattered stands of timber along some hillsides, rivers and ponds. The Southern Long Range Mountains, penetrated by forested river valleys, border the west and south. The northern third of the area is boreal forest; pulp cuts and associated logging roads are common there. Elevations range from 275 m on the floor of river valleys to 670 m on hilltops; flatter terrain averages 450 m. Our intensive 225-km² study area (Figure 1) was located on the south-central portion of Dashwoods on typical barrens.

Forest cover is predominately mature Balsam Fir, *Abies balsamea*, but includes Black and White spruce, *Picea mariana* and *Picea glauca*, and White Birch, *Betula papyrifera*. Barrens have extensive patches of fir and spruce scrub (< 3 m high), ericaceous heath

NEWFOUNDLAND



FIGURE 1. Location of the Dashwoods Moose Management Unit and study area in Newfoundland.

vegetation, bogs, and ponds. Common plants include Labrador Tea, *Ledum groenlandicum*, Rhodora, *Rhododendron canadense*, Sheep Laurel, *Kalmia angustifolia*, and Larch, *Larix laricina*.

Summers are cool and wet, and winters are severe. Snow normally begins to accumulate in November and may persist into May or June. Thicknesses range from several cm on windswept hilltops to 4 m on drifted slopes; maximum thicknesses in woods average about 1.5 to 2.0 m. Snow is normally windpacked, strongly crusted, and fully or partially supportive of Moose during much of the winter. Mean July and February temperatures are 10°C and -8°C, respectively.

The Black Bear, *Ursus americanus*, is a potential predator of Moose calves on the Dashwoods area; the Lynx, *Lynx canadensis*, is perhaps another (W. E. Mercer, personal communication).

Methods

Marking, Relocation, and Sex and Age Determination

During March and November 1983 we darted and immobilized 32 Moose from a Bell 206 helicopter using etorphine hydrochloride and acepromazine maleate (Immobilon) alone or mixed with xylazine hydrochloride (Rompun). Two additional animals

were stalked on foot and darted; another was darted from a snowmobile. A canine was pulled from 26 of 30 adults and used for ageing by cementum annuli (Sergeant and Pimlott 1959; Gasaway et al. 1978). Interpretation of annuli was done by Matson's Laboratory (Milltown, Montana); they estimated accuracy at about 80%, with errors being ± 1 year.

Ear tags and neck collars with color-coded symbols were placed on adults; calves were marked with colored ear streamers. Radio transmitters were attached to collars (23) or to ear tags (12). All 12 ear-tag transmitters and 10 of the collar transmitters were solar-powered.

Marked Moose were relocated with binoculars and spotting scopes, and through ground and aerial radio tracking. Locations of both marked and unmarked Moose were plotted on 1 : 50 000 topographic maps. Home ranges were estimated by the minimum-perimeter-polygon method (Mohr 1947).

Calf-cow ratios and population sex and age structure were obtained from ground and aerial observations. Sex was determined by presence or absence of a vulva patch (Mitchell 1970), antlers, or a calf. Bull- and calf-cow ratios and percentage of calves in the population, as determined from ground vs. aerial sightings, did not differ ($P > 0.25$) during fall (September-December) 1983. We therefore used both types of observations when calculating seasonal means.

Census

Moose numbers were estimated on the entire 2936-km² Dashwoods area during February 1983. We used a stratified random sampling design (Siniff and Skoog 1964) based on prior knowledge of Moose distribution in winter. Counts of 125 4-km² quadrats comprising 17% of the area were made from a Cessna 185. Flight patterns were transects or intensive circling, depending on topography and forest cover. Sixteen quadrats were resurveyed by helicopter within 2 hours of the fixed-wing counts; this provided an estimate of uncounted moose, and yielded a sightability correction factor of 2.3. Fixed-wing and helicopter searches averaged 9 and 12 minutes/quadrat, respectively.

Winter Range Measurements

Various browse and stand-condition measurements were taken in five woods on our study area during summers 1983 and 1984. These woods were used by Moose during winter, and were typical of others scattered over the south-coast barrens. They ranged from 25 to 200 ha and were 80-90% Balsam Fir; Black Spruce and White Birch were also present. Because we noted that Balsam Fir was the predominant winter food and cover of Moose on the barrens, our surveys focused on this species.

We recognized four height classes: mature trees (>3.5 m), tall regeneration (1.5–3.5 m), short regeneration (0.5–1.5 m), and seedlings (<0.5 m). Trees were further classified by breast height circumference (20–39, 40–59, 60–79, or 80+ cm). A random sample was obtained within each circumference class in each woods to determine tree height, browse-line height, and age. Heights were measured with a Suunto clinometer or a tape. Trees were aged by felling and counting growth rings under a magnifying glass. Increment-bored samples were uninterpretable due to the closeness of annual rings.

Thirty 1/200-ha circular quadrats were examined in each woods to obtain density of both live and dead Balsam Fir trees and fir regeneration, and to measure impact of Moose browsing. Quadrats were located systematically on transects running at right angles to topographic contours. The distance between transects and plots averaged 100 m and 50 m, respectively.

The intensity of Moose browsing on fir regeneration (individual plants) was classified as none, light, moderate, or heavy (defined in Table 11, footnotes a and b). Both the accumulated amount of past browsing and that during winter 1983–84 were recorded. The latter was recognized by the freshness of remnant twig stubs. Accumulated browsing on seedlings was also rated in each quadrat.

The proportion of live fir trees and regeneration that provided browse for Moose during late winter 1984 was calculated to determine the effect of snow accumulation on browse availability. Browse was available between snow level (mean thickness measured in late March — 0.8 to 1.4 m) and 2.4 m above it (the observed maximum reach of adult Moose on fully supportive snow). Belt transects 1.9 m wide were walked during summer 1984, and those trees and regeneration that could have provided browse in late-winter were tallied; the number actually

browsed was also recorded. The area sampled was calculated from transect width and total length. Estimates of tree and regeneration densities from quadrat sampling were used to obtain numbers alive within transects. Percentage of plants with browse available during late winter was thus the number tallied divided by the number in transects.

Statistical Tests

Chi-square tests (2×2 and 3×3 contingency tables) were used to obtain probabilities (P) when comparing ratios or percentages. Probabilities when comparing means were determined from t tests for unpaired data.

Results

Population Density

Mercer and Manuel (1974) estimated Moose density on the south-coast barrens at $>1.9/\text{km}^2$ ($5/\text{mi}^2$) during the population peak that occurred about 1960. A census by helicopter of the Dashwoods Management Unit during winter 1973 indicated a decline of about 50% to $0.8/\text{km}^2$. Our population estimate in winter 1983 was also $0.8/\text{km}^2$ (Table 1).

The confidence interval on the latter estimate was wide due to high variance in the sightability correction factor (see Table 1, footnote c). However, that the density in 1983 was comparable to 1973 was further indicated by the fact that there was (1) no difference between years in mean numbers of Moose counted/quadrat from a helicopter in high-density ($P = 0.07$) and medium-density strata ($P > 0.10$); and (2) by the similarity of population indices derived from hunter reports (e.g. Moose seen/hunter-day, and moose shot/hunter-day; W. E. Mercer, unpublished data).

Moose densities on the northern half of Dashwoods (primarily forest) were much lower than those on the southern barrens, viz., 0.2 vs. $1.4/\text{km}^2$ in winter 1973, and 0.3 vs. 1.3 in 1983. These density estimates are not

TABLE 1. Population estimates for Moose on the 2936- km^2 Dashwoods Management Unit, southwestern Newfoundland.

Month and year	Census method	Aircraft used	Moose population estimate	90% CL	Moose/ km^2
1960	Visual estimate ^a				>1.90
February 1973	Counts within random quadrats ^b	Helicopter	2302	1376–3228	0.78
February 1983	Counts within stratified-random quadrats	Fixed-wing and helicopter ^c	2338	864–3812	0.80

^aMercer and Manuel (1974), for south-coast region.

^bData from this survey were re-analyzed by assigning quadrat counts to 1983 strata because the management-unit boundaries changed between 1973 and 1983.

^cInitial counts were made from fixed-wing aircraft. A correction factor for Moose not seen was developed from helicopter counts made within 2 h of fixed-wing searches in 16 quadrats. The correction factor and its variance were estimated according to Jessen (1978, section 5.3).

TABLE 2. Observed sex ratios and calf-cow ratios on the Dashwoods area, southwestern Newfoundland during fall and spring. Sample sizes are shown in parentheses.

Season and year	Type of observation ^a	Adult and yearling sex ratio (bulls : cows)	Calves/100 yearling and adult cows	% Calves
Fall (6 September-5 December)				
1979 ^b	Aerial	33 : 67 (27)	44 (18)	23 (35)
1982	Ground	24 : 76 (29)	41 (22)	20 (44)
1983	Aerial and ground	22 : 78 (272)	56 (211)	29 (411)
Means ^c and totals		26 : 74 (328)	47 (251)	24 (490)
Spring (22 March-19 May)				
1983	Ground	19 : 81 (36)	17 (29)	7 (71)
1984	Ground	15 : 85 (155)	49 (131)	26 (250)
Means ^c and totals		17 : 83 (191)	33 (160)	17 (321)

^aAll aerial observations were made from a helicopter.

^bThese observations were made in the extreme southern portion of the Dashwoods area in November (W. R. Skinner, unpublished data).

^cUnweighted means were calculated because of the large difference in sample size among years and the markedly higher proportion of calves in 1983-84.

biased by a regional difference in visibility of Moose during census flights: Moose on the barrens occupied woods in winter, as did those further north, and the sightability correction factor (fixed-wing vs. helicopter) in each region was 2.3. The difference in density may reflect higher harvest rates in the north due to better road access. The total reported kill in the north during 1976-82 was 1.5 times that in the south (Newfoundland Wildlife Division, unpublished data). A highway and numerous logging roads penetrate the north, but the southern barrens are accessible by aircraft only.

Sex and Age Structure

The mean bull-cow ratio changed from 27 : 73 (N = 303) in summer (July-August) to 17 : 83 in spring (March-May) (Table 2). As shown later, the decreased proportion of bulls in spring reflected their differential harvest (1.5 bulls/cow) during fall (Newfoundland Wildlife Division, unpublished data).

The sex ratio of calves of radio-collared cows during 1982 and 1983 was 75 : 25 (N = 12); the ratio among other calves was 48 : 52 (N = 21). The sex ratio of calves tagged on the south-coast barrens during 1973-75 was 56 : 44 (N = 90) (W. R. Skinner, unpublished data).

TABLE 3. Observed and calculated age distributions of Moose on the Dashwoods area, southwestern Newfoundland, during 1982-84.

Type of sample	Season	% In each age class (year)			N
		1.5	2.5	≥3.5	
Bulls					
Ground observations ^a	Fall	---	53---	47	47
Demographic calculation (1)	Spring	53 ^b	---	47---	
(2)	Spring	31 ^c	---	69---	
(3)	Spring	56 ^d	---	44---	
Cows					
Radio-collared ^e	Fall	6	11	83	18
Demographic calculation (1)	Spring	14 ^b	---	86---	
(2)	Spring	12 ^c	---	88---	
(3)	Spring	21 ^d	---	79---	

^aClassification based on antler size in relation to antler development of bulls aged by dental annuli (15 August-24 November 1983).

^bYearling composition assuming that annual losses are exactly replaced by yearling recruitment (see section on survival).

^cYearling composition calculated from the winter population estimate of 2338 and the prehunt bull-cow ratio of 27 : 73, assuming the 17% calves in the spring population are recruited at a sex ratio of 50 : 50.

^dYearling recruitment needed to change the sex ratio from 17 : 83 in spring to 27 : 73 in summer, assuming that yearlings are recruited at a sex ratio of 50 : 50.

^eNovember 1982 ages of cows marked during 10 March-16 November 1983.

The estimated 47% (31–56%) yearling bulls in the population (Table 3) exceeded the 22% in the hunting kill (Newfoundland Wildlife Division, unpublished data), likely due to selection by nonresident hunters for older bulls with large antlers. Five of our seven known-age bulls (darted as encountered) were yearlings (1982 ages).

Yearlings constituted an estimated 13% (6–21%) of adult cows in the population but 21% of the kill, suggesting differential vulnerability to hunting as reported also by Pimlott (1959a), Simkin (1965), and Crête et al. (1981). The ratio of yearlings to 2-year-olds to ≥ 3 -year-olds, as determined by dental annuli, did not differ ($P \geq 0.10$) among bulls or among cows shot by hunters during the first ($N = 84$), second ($N = 146$), and last third ($N = 171$) of the 1973–82 sampling period. This indicates an age-stable population as we have no reason to believe that hunter selectivity changed during the period.

Productivity

We first observed newborn calves on 15 May 1983 and 27 May 1984. Calf-cow ratios during 1979–84 averaged 47 : 100 in fall and 33 : 100 in spring (Table 2). Twins were rare in this region: two sets were encountered while tagging 90 calves during 1973–75 (W. R. Skinner, unpublished data) and only one set was seen in 261 calf-cow groups during our study. The $< 1\%$ twins observed by us in summer ($N = 107$ calf-cow groups) was among the lowest on record (Rolley and Keith 1980).

We estimated age-specific reproduction by monitoring marked cows whose age was determined from dental annuli. Our estimates of calf production are minimal because 24 of 53 cow observations to check for calves were made 4 to 12 months postpartum (10 during September–November, and 14

TABLE 5. Calf-cow ratios on the Dashwoods area during 1982–84 in relation to snow accumulation the previous winter. Number of cows is shown in parentheses.

Snow thickness (m) in woods by March	Year of calf-cow observations	Calves/100 yearling and adult cows		
		Summer	Fall	Spring
> 2 m 1982	1982–83	21 (34)	41 (22)	17 (29) ^a
< 1 m 1983	1983–84	47 (149) ^b	56 (211)	49 (131) ^a
1–2 m 1984	1984–85	21 (121) ^b		

^aRatios differ significantly ($P < 0.05$).

^bRatios differ significantly ($P < 0.005$).

during March–May). However, the pooled 1982–84 calf-cow ratio obtained by 8 June (40 calves/100 cows, $N = 20$ cows), 1 to 21 days after parturition, was similar to that obtained when cows were first observed during the subsequent March–May period (43 calves/100 cows, $N = 14$ cows). Survival of these radio-collared cows was 100%, thus essentially all calf mortality occurred shortly after birth (before we could observe calves), or alternately, first-year losses were negligible.

We found no good evidence of calf production by cows < 4 years old (Table 4). We suspect this reflects primarily an absence of conceptions rather than a total loss of calves among 2- and 3-year-old cows. Additional evidence of low reproduction was provided by the $< 1\%$ twinning rate, and the fact that in only 3 of 17 cases were cows ≥ 4 -years-old seen with calves in consecutive years. Only 1 of 7 cows was with a calf in all three years.

Calf-cow ratios were higher after a winter (1982–83) with little snow accumulation than after two others in which snow thicknesses were average or above (Table 5). Calves constituted 26% of the March–May population in 1984 following the largely snow-free winter of 1982–83, but just 7% in 1983, one year after a winter of deep snow (Table 2).

Survival

Adults: Annual losses of adults (≥ 1 -year-old) in this stationary Moose population will on average equal yearling recruitment to the adult cohort each spring. Our best estimate of such recruitment is 397 (Table 6): the total late-winter (February) population of 2338 (Table 1) times the 17% calves (short-yearlings) in spring (late March–mid May) (Table 2). The reported mean annual hunting kill of 448 adults during 1982 and 1983 would thus account for all adult losses annually.

A second estimate of hunting mortality relative to total adult losses was obtained from the pre- and posthunt bull-cow ratios of 27 : 73 (summer) and

TABLE 4. Minimum age-specific reproductive rates of cows aged by dental annuli on the Dashwoods area, southwestern Newfoundland. Earliest observations of cows to assess calf production are described in text. Number of cows is shown in parentheses.

Age class at calving (year)	Calves/100 cows			
	1982	1983	1984	Totals
2.0		0 (1)	0 (1)	0 (2)
3.0	0 (2)	0–33 ^a (3)	0 (1)	0–17 (6)
≥ 4.0	50 (8)	67 ^b (15)	45 (11)	56 (34)

^aA calf was observed within 100 m of two 3.5-yr-old cows when they were radio-collared on 16 November 1983, but it appeared unattached to either.

^bIncludes one calf (in-utero) of a cow which died when darted (25 April 1983).

TABLE 6. Calculated mean annual harvest rate of adult Moose on the Dashwoods Management Unit, southwestern Newfoundland, based on data obtained during the present study and from the Newfoundland Wildlife Division.

Total population in late winter (February)	2338
Calves (17%) in population in spring (late March-mid May)	397
Adults in population in late winter	1941
Adults shot by hunters in previous fall (September-October)	448
Total adults in fall population	2389
Harvest rate (448/2389) assuming no nonhunting losses of adults during September-February	19%

17 : 83 (following spring), the bull-cow ratio of 60 : 40 in the hunter kill, and the calculated yearly harvest of 19%. The 19% kill rate (Table 6), coupled with the 60 : 40 sex ratio in the harvest, could shift the bull-cow ratio of 27 : 83 in summer to 19 : 81 after the hunting season (Table 7). The observed spring sex ratio of 17 : 83 could be produced by additional year-round nonhunting losses of 6% that removed equal numbers of bulls and cows. This latter assumption is not likely correct, but it is the simplest needed to generate the spring sex ratio. These calculations indicate that hunting mortality may account for 76% $[19/(19 + 6)]$ of adult losses annually.

From the above data we estimated annual survival at 47% among adult bulls, 86% among adult cows, and 75% overall (Table 7).

Survival of cows was also estimated in a composite life table analysis using an 18% ($N = 111$) sample of those shot by hunters during 1973-82. We assumed that the age distribution of the kill reflected that of the population and considered it a sample of the living. We also assumed that the population was stationary and age-stable (see earlier section on population structure and Table 1). Yearlings were deleted from this analysis because, as shown earlier, they were probably more vulnerable to hunting than were older cows. Mean annual survival of cows aged 2 to 9 years was 84%. The age distribution of harvested bulls was inappropriate for a life table due to hunter selection for larger (older) individuals.

Calves: Due to the timing of field work, it was only during 1983-84 that we could monitor survival of calves born to radio-collared cows over a full year. Six radio-collared cows were located with calves by 17 June 1983 (within four weeks of parturition) and monitored past 15 April 1984; all six calves survived.

TABLE 7. Calculated survival of adult Moose on the Dashwoods Management Unit, southwestern Newfoundland, based on data obtained during present study and from the Newfoundland Wildlife Division.

Given: Hypothetical population of 1000 adults (≥ 1 -year-old)			
Preharvest (July-August) bull-cow ratio in population of 27 : 73			
Annual harvest rate of 19%			
Bull-cow ratio in harvest of 60 : 40			
Postharvest (late March-mid May) bull-cow ratio in population of 17 : 83			
Then:	Bulls	Cows	Total
Preharvest population	270	730	1000
Number harvested	114	76	190
Postharvest population	156	654	810
Postharvest bull-cow ratio is 19 : 81 without nonhunting mortality			
Nonhunting mortality needed to generate a bull-cow ratio of 17 : 83 by spring (late March-mid May) if equal number of bulls and cows die			
	28	28	56
Spring (late March-mid May) population	128	626	754
Spring bull-cow ratio after hunting and nonhunting mortality is 17 : 83			
Annual survival rate of bulls $(128/270) = 47\%$			
Annual survival rate of cows $(626/730) = 86\%$			
Total annual survival rate $(754/1000) = 75\%$			

We also made two demographic calculations of average calf survival from changes in calf-cow ratios over the year (Table 2 and text), the proportion and fecundity of cows ≥ 4 -years-old (Table 4), and cow survival (see text). We assumed that most calf-cow pairs remained together through the spring observation period of 22 March-19 May because six of nine radio-collared cows were with their calves of the previous year past 21 May in 1984. Eleven-month (May-April) survival of calves was thereby estimated at 71% (annual rate of 0.69; Table 8). As noted earlier, this excludes possible losses of calves before our first observations at about 1 through 21 days of age. Mean 6-month (October-April) survival was estimated at 64%. If, contrary to our assumption in Table 8, all calves of cows that died *did not* also die, then

TABLE 8. Calculated annual calf survival on the Dashwoods area, southwestern Newfoundland.

(1) Annual calf survival estimate

Calculated calf-cow ratio shortly after birth in late May:

Proportion of radio-collared cows that were ≥ 4 -years-old (1982 ages) — 0.72

Calves/cow ≥ 4 -years-old (Table 4) — 0.56

Calves/yearling and older cow — $0.72 \times 0.56 = 0.40$

Estimated calf-cow ratio in late May: 40 calves : 100 cows

Mean spring calf-cow ratio from ground observations (average observation date of 20 April, $N = 160$ cows): 33 calves : 100 cows

Apparent calf survival rate (11 months): $33/40 = 0.83$

May-April (11 months) cow survival rate^a: 0.86

May-April calf survival rate corrected for cow survival: $0.83 \times 0.86 = 0.71$

Annual (12 month) survival rate of calves: 0.69^b

(2) October-April calf survival estimate

Mean fall calf-cow ratio from ground and aerial observations (average observation date of 21 October, $N = 251$ cows): 47 calves : 100 cows

Mean spring calf-cow ratio from ground observations (average observation date of 20 April, $N = 160$ cows): 33 calves : 100 cows

Apparent calf survival rate (6 months): $33/47 = 0.70$

October-April (6 months) cow survival rate^a: 0.92

October-April calf survival rate corrected for cow survival: $0.70 \times 0.92 = 0.64$

^aMean annual rate of 0.85 as calculated from demographic data (0.86) and from a life table analysis (0.84).

^bExpanded to 12 months assuming constant rate of survival.

calculated survival of calves during May-April and October-April could increase from 71% to 86% and from 64% to 70%, respectively. Comparison of these two pairs of survival estimates suggests low rates of loss during June-September.

Movements

We measured the distance between "winter" locations and "summer" home range centers (based on pooled 1983 and 1984 locations) of 21 radio-collared Moose. Summer home ranges were outlined by 7-54 sightings of 13 Moose, 4 of 7 others, and just 3 sightings of another. Winter locations were obtained after Moose had moved from the open barrens to wooded wintering sites. Most (92%) of the 62 winter

locations were within 10 km of summer home range centers (Figure 2). The mean distance between summer home ranges and winter locations did not differ ($P > 0.10$) when the former were based on 7-54 vs. 3-4 sightings.

Of the 14 radio-collared Moose located between 24 November and 12 December 1983, 11 still occupied their summer ranges. The other three had moved to wintering areas in November or early December. Most movements from summer ranges occurred between 12 December and 3 February with onset of heavy snow accumulation. Only one of the 21 radio-collared Moose located during February and March had not moved from its summer range on the barrens. We first observed Moose returning to open barrens (typical summer range) on 7 April 1983 and 19 April 1984, after snowmelt began. All 14 radio-collared Moose with which we had contact had returned to their summer ranges within two weeks of these dates.

Radio-collared Moose used four cover types as wintering sites. Patches (< 25 ha) of mixed conifer scrub and isolated stands (25-200 ha) of Balsam Fir timber accounted for 42% and 35%, respectively, of 62 locations, 19% were in forested river valleys, and 4% in extensive (> 200 ha) forest. Seven of 13 radio-collared Moose observed in consecutive winters were found in exactly the same woods or river-valley site on 78% of 27 total relocations; five other Moose were within 6 km of their previous year's locations.

Nine of 90 moose tagged as calves on the south-coast barrens by Newfoundland Wildlife Division personnel during 1973-75 were later reported shot by hunters. Distances traveled from tagging locations ranged from 5 to 50 km and averaged 25 km (W. R. Skinner, unpublished data). Movements of 23 and

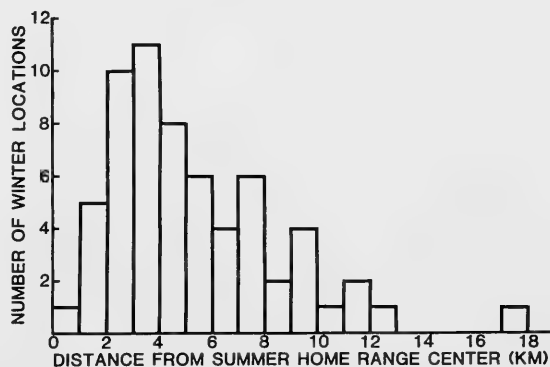


FIGURE 2. Frequency distribution of distances between summer range centers of 21 radio-collared Moose and their winter locations during 1983 and 1984 on the Dashwoods area, southwestern Newfoundland. Total number of winter locations was 62.

TABLE 9. Age structure of live Balsam Fir trees in five woods on the Dashwoods area during summer 1984. The number of trees aged to determine circumference-age relationship is shown in parentheses.

Woods	Tree circumference 40+ cm	Percentage of trees in size class ($\pm 90\%$ CL)	Tree circumference 20–39 cm	Percentage of trees in size class ($\pm 90\%$ CL)
	Mean age (years) ^a		Mean age (years)	
Rocky Pond	104 (11)	83 \pm 17	63 (2)	17 \pm 10
Old Campsite	104 (10)	84 \pm 16	59 (4)	16 \pm 8
Caribou Pond	96 (9)	61 \pm 11	65 (3)	39 \pm 13
Hearn's	96 (15)	76 \pm 23	60 (2)	24 \pm 19
Whale Back	60 (13)	70 \pm 10	48 (10)	30 \pm 11

^aStandard errors ranged from 1 to 15 in the 20–39 cm class and from 3 to 9 in the 40+ cm class.

29 km by two bulls shot as yearlings were similar to the 18, 21, 24 and 42 km moved by four others shot at ages 2.5 to 9.5 years. Thus Newfoundland Moose, like those elsewhere (Lynch 1976; Mytton and Keith 1981), likely disperse initially as yearlings.

Condition of Vegetation in Wintering Areas

The five woods sampled were primarily composed of mature Balsam Fir trees 10 to 12 m high. Densities of live fir trees ranged from 466–1747/ha, and fir regeneration (0.5–3.5 m high) from 1360–1937/ha. The lowest live branches of trees were 3.4–4.6 m ($N = 174$) above ground level, due to browsing by Moose and natural pruning. Regenerating fir predominated in the understory; Black Spruce regeneration was also present, but no White Birch.

Age structure of fir stands was determined from the mean age of each of four circumference classes (see methods), and the estimated number of trees present per class. In four woods, 61–84% of the trees averaged 100 years old, but the majority in another (Whale Back) were about 40 years younger (Table 9). Many trees were decrepit, with dead tops and lateral branches.

The proportion of regenerating and older fir that was dead but still standing averaged 40% for short regeneration, 74% for tall regeneration, and 33% for trees (Table 10). Most dead regeneration had apparently been killed by past Moose browsing. The high proportion of dead trees had created open forest canopies. Crown closure of our five woods, as determined from Newfoundland and Labrador Forest Inventory maps (1966–69), ranged from 41 to 70%. Five 30-m line intercepts conducted by us in each of three woods (Hearn's, Rocky Pond, and Old Campsite) gave crown closures of 45 to 49%.

Past Moose browsing was on average moderate-to-heavy on 67% of short regeneration and 80% of tall ($P = 0.001$) (Table 11). Browsing of these same regeneration classes over winter 1983–84, however, averaged just 5 and 4% (Table 12). Browsing on

seedlings was rated as moderate-to-heavy in 53, 60, and 67% of the quadrats sampled in Hearn's, Rocky Pond, and Old Campsite Woods, respectively, but few were browsed in the other two woods.

By late winter 1984 (approximately 1 March–15 April), snow accumulation had reduced the availability of live fir regeneration to just 16% of that available without snow (Table 13). During this period, 31% of the live fir trees provided small amounts of browse, mainly from resprouting on trunks. There was little browsing on either trees or available regeneration in late winter 1984, except at Whale Back Woods where 32% of the regeneration was browsed to some degree (Table 13).

Discussion

Winter Range Conditions

During December–April, Balsam Fir is the sole source of food for Moose on much of Dashwoods; other palatable browse species are either snow covered or absent. Winter food was scarce in the five woods we surveyed. Mature trees were potentially

TABLE 10. Percent ($\pm 90\%$ CL) of Balsam Fir trees and regeneration that were dead but standing in five woods on the Dashwoods area, southwestern Newfoundland. Total number of trees and regeneration tallied in sample plots is shown in parentheses.

Woods	% Dead but standing		
	Trees (> 3.5 m)	Tall regeneration (1.5–3.5 m)	Short regeneration (0.5–1.5 m)
Hearn's	63 \pm 15 (188)	74 \pm 26 (176)	34 \pm 10 (233)
Old Campsite	31 \pm 9 (265)	83 \pm 21 (124)	50 \pm 13 (250)
Rocky Pond	30 \pm 8 (224)	54 \pm 17 (135)	27 \pm 8 (262)
Whale Back	25 \pm 6 (331)	85 \pm 18 (337)	46 \pm 15 (316)
Caribou Pond	18 \pm 6 (321)	76 \pm 31 (267)	44 \pm 13 (390)
Means	33	74	40

TABLE 11. Impact of past browsing by Moose on individual stems of Balsam Fir regeneration in five woods on the Dashwoods area, southwestern Newfoundland.

Woods	% Of tall regeneration (1.5–3.5 m) browsed		Number of plants examined	% Of short regeneration (0.5–1.5 m) browsed		Number of plants examined	<i>P</i> ^c
	Moderate- Heavy ^a	None- Light ^b		Moderate- Heavy	None- Light		
Old Campsite	100	0	21	81	19	125	0.017
Hearn's	79	21	42	60	40	148	0.014
Whale Back	77	23	49	63	37	170	0.045
Caribou Pond	73	27	63	72	28	208	0.788
Rocky Pond	69	31	62	60	40	189	0.181
Mean	80	20		67	33		0.001

^aPlant growth obviously slowed or stopped, and form of plant severely altered.^bPlant growth and growth form not obviously affected.^c*P*-values indicate significance of differences in ratios of Moderate-Heavy to None-Light browsing of tall vs. short regeneration.

browsable only during winters when snow thicknesses were sufficient (>1.8 m) to elevate Moose to the lowest live branches (average 4.2 m above ground level). Understory regeneration was largely snow-covered by late winter (Table 13), and most available regeneration was already moderately-to-heavily browsed (Table 11). Nonetheless, Moose continue to concentrate in these woods during winter, often at high densities. Counts by helicopter of Rocky Pond Woods (1 km²) during March 1983 and February 1984 revealed 9 and 11 Moose, respectively. Twenty Moose were observed in Old Campsite Woods (2 km²) from a fixed-wing aircraft during January 1983, and 27 were observed from a helicopter during February 1984.

The higher browsing intensity on tall vs. short regeneration reflected its greater availability during winter (Table 11). Although current browsing is apparently light during a single winter (Table 12), it is

evidently sufficient to suppress growth, even in the absence of overstory shading. Few stems of advanced tall regeneration (3.0–3.5 m) were unaltered by browsing.

During normal or mild winters (accumulated snow thickness <1.8 m), patches of fir scrub adjacent to woods are probably the major source of food for Moose. Radio-collared Moose were found in this cover type on 42% of 62 winter locations, as were 47% of 330 Moose observed during our 1983 aerial census. Moreover, all 15 Moose observed in a census block containing most of Old Campsite Woods were standing in a large area of adjacent scrub.

We believe the scattered woods on open barrens serve primarily as winter cover for Moose, and only secondarily as food sources. Such timbered sites probably reduce radiant heat loss, especially during strong winds that accompany the frequent winter storms. Pimlott (1953) found unbrowsed fir

TABLE 12. Impact of browsing by Moose on individual stems of Balsam Fir regeneration in five woods on the Dashwoods area, southwestern Newfoundland, during winter 1983–84.

Woods	% Of tall regeneration (1.5–3.5 m) browsed		Number of plants examined	% Of short regeneration (0.5–1.5 m) browsed		Number of plants examined
	Moderate- Heavy ^a	None- Light ^b		Moderate- Heavy	None- Light	
Old Campsite	10	90	21	8	92	125
Hearn's	2	98	42	2	98	148
Whale Back	4	96	49	7	93	170
Caribou Pond	4	96	63	6	94	208
Rocky Pond	0	100	62	5	95	189
Mean	4	96		5	95	

^aPlant growth obviously slowed or stopped, and form of plant severely altered.^bPlant growth and growth form not obviously affected.

TABLE 13. Browse availability and utilization by Moose during late winter 1984 (March-April).

Woods	% Live Balsam Fir trees		% Live Balsam Fir regeneration	
	Potentially browsable ^a	Actually browsed ^b	Potentially browsable	Actually browsed
Hearn's	56	5	11	0
Rocky Pond	47	2	14	8
Old Campsite	19	14	1	0
Whale Back	22	2	15	32
Caribou Pond	13	3	37	14
Mean	31	5	16	11

^aBrowse was available during late winter up to 2.4 m above mean snow thickness (0.8–1.4 m).

^bBrowsing may have occurred in the lower portion of each availability zone all winter whereas higher browse could only be reached following snow accumulation.

regeneration in those parts of overbrowsed range without interspersed forest cover. A juxtaposition of woods (cover) and fir scrub (food) is likely a habitat requisite of Moose wintering on the barrens. Mature fir trees may be an important food source during winters of deep snow (>1.8 m). However, there was little evidence of browsing in the canopies of trees felled by us.

Balsam Fir is generally short-lived, being host to a variety of fungi and rots that increase susceptibility to windthrow (Barrett 1980). A commercial rotation of 80 years was recommended in Newfoundland to avoid such problems (Robertson 1945). Both the ages of trees in the five woods examined on Dashwoods (Table 9), and the large proportion that were dead (Table 10), indicated senescence, and that stand die-off is imminent if not already underway.

Fir forests undisturbed by fire or logging are the stable, climax state in Newfoundland (Damman 1964). As canopy closure diminishes in older stands due to logging or windthrow, advanced fir regeneration is released and the stand is restocked to fir (Damman 1967; Bergerud and Manuel 1968). Under conditions prevailing on Dashwoods, however, Moose browsing has suppressed and severely altered regeneration (Table 11). A transition to fir scrub or sparsely stocked Black Spruce stands seems inevitable with continued browsing. Spruce regeneration was not abundant, though rarely browsed by Moose. Snyder and Janke (1976) reported lower densities of Balsam Fir and higher densities of White Spruce on Moose browsed vs. unbrowsed sites on Isle Royale, Michigan.

Conversion of extant fir woods on the barrens of Dashwoods to open spruce or fir scrub would undoubtedly decrease their attractiveness to wintering Moose, and prompt movements into adjacent river

valleys and other forested sites. We did not measure browsing intensity in these other areas, but noted that many are already heavily utilized. Six of the eleven 4-km² blocks in river valleys and extensive forest surveyed by helicopter in winter 1973 contained 12 to 31 Moose; eight of 49 such blocks surveyed by fixed-wing in 1983 held 10 to 32 Moose.

Population Demography

Factors Affecting Productivity: Several of our productivity indices (low twinning rate, paucity of newborn calves with radio-collared cows, and infrequent consecutive-year calf production) suggested low reproduction and/or high calf losses immediately postpartum. Three factors may have been involved: (1) low ovulation rates due to poor nutrition, (2) low fertilization rates due to low bull-cow ratios, and (3) prenatal and early postnatal death due to poor nutrition during pregnancy and/or early postnatal losses from predation.

Franzmann and Schwartz (1985) suggested using twinning rates to assess the nutritional status of Moose range. In general, low rates occur where range conditions are poor and/or the winter climate is severe with persistent deep snow and low temperatures (Blood 1974; Markgren 1974a). The low rate of twinning on Dashwoods was not due to an unusually high proportion of young adults in the female cohort: no twins accompanied the 12 cows who were, according to dental annuli, in their prime reproductive years (age 6 to 14 years). The virtual absence of twinning on Dashwoods likely signals an inadequate winter food supply relative to the energy demands created by the harsh winter environment. We did not study summer nutrition and will not speculate on its significance, except to note that reproduction of both Moose and Mule Deer, *Odocoileus hemionus*, has

allegedly been affected by food quality of summer range (Markgren 1974a; Robinette et al. 1955; Julander et al. 1961).

In Sweden, cows not conceiving as yearlings usually do so when 2.5 years old (Markgren 1969). Age-specific pregnancy rates in North America indicate a similar situation (Simkin 1974). The apparent failure of 2.5-year-old cows to conceive on Dashwoods implies unusually late maturation. Pimlott (1959a) proposed that the level of nutrition experienced by a calf during its first winter determines whether puberty is attained the following fall. However, studies of White-tailed Deer, *Odocoileus virginianus*, fawns suggest that nutrition during the subsequent summer is more important (Verme 1967). Bergerud et al. (1968) observed productivity similar to that on Dashwoods in a heavily browsed region of central Newfoundland during the mid 1960s: no twin calves or yearlings with calves, and no ovulation by four 2.5-year-old cows.

Low consecutive-year calf production among cows ≥ 4 years old could reflect the combined effects of poor winter nutrition and the physiological demands of lactation throughout summer. In White-tailed Deer, for example, productivity is related to weight gain following parturition: barren does and those whose offspring die at birth subsequently achieve higher fawning rates than do lactating does (Verme 1967). Does that are severely malnourished during fall have late, irregular estrus or may not breed at all (Verme 1965). Lactation also influences weight gains of Moose: in Alaska lactating cows weighed approximately 50 kg less than nonlactating cows by the end of June (Gasaway and Coady 1974).

Chronic low calf production on the Dashwoods area may in part signify a lack of food diversity rather than food shortage *per se*. As noted earlier, Balsam Fir is the sole food source in winter on Dashwoods. Oldemeyer et al. (1977) concluded that a diversity of browse best meets the nutritional needs of Moose. Among other northern herbivores, neither the Snowshoe Hare, *Lepus americanus*, nor Arctic Hare, *L. timidus*, can long subsist on a single browse species regardless of its abundance, palatability and digestibility (Bookhout 1965; Pehrson 1981; J. P. Bryant, personal communication).

The sex ratio of Moose at birth is commonly 53–58% males (Pimlott 1959b; Simkin 1965; Haagenrud 1979), but disproportionate harvests of bulls usually result in a preponderance of cows among adults (Markgren 1974b). The reproductive consequences of markedly unbalanced adult sex ratios favoring females are unknown, but there is some evidence of reduced fertilization rates in Moose and Elk, *Cervus elaphus*, populations when this imbalance

combines with low density and/or a high proportion of yearlings among adult bulls (Markgren 1969, 1974b; Hines and Lemos 1979). Yearlings allegedly search less intensively for cows during the rut than do mature bulls (Markgren 1974b). Population density and age composition may be less important in North America than in Europe where cows reportedly do not vocalize nor actively seek bulls during the rut (Markgren 1974b).

We used a fall population of 2389 adults (Table 6), a summer bull-cow ratio of 27 : 73, and the population's age structure (Table 3) to calculate bull-cow ratios on Dashwoods. Four cows ≥ 3.5 years old, or 5 cows ≥ 1.5 years old were present in fall for each bull ≥ 2.5 years old. Intensive bull-only hunting beginning about 10 September, 2 to 3 weeks before the main estrus (W. R. Skinner, unpublished data), undoubtedly creates an even greater imbalance. Considering the 7 to 12 day courting tendency of bulls (Altmann 1959), and the < 24 -hour period of cow receptivity (Markgren 1969), the potential for unbred cows seems high to us. Bull-cow associations on Dashwoods comprised only 10% of the 97 total groups observed (including single animals) during 16 September–15 October 1983, and 8% of 97 during 16 October–30 November. In contrast, during these same two periods bull-cow associations comprised 34 and 44% of total groups in Alaska, 33 and 26% in Minnesota, and 25 and 19% in Montana (Peek et al. 1974).

We recorded two probable instances of late (second estrus) breeding. A radio-collared cow without a calf on 21 June was accompanied by a newborn calf six days later. That birth occurred approximately 30 days after the calving peak in late May; the period between successive estruses is 25 to 30 days (Edwards and Ritcey 1958; Markgren 1969). Another cow was observed with a notably small calf on 17 August. Copulation by a small fork-antlered bull was observed on 18 October (about three weeks after the main estrus period).

Intrauterine and early postnatal losses due to winter weather may also have reduced productivity. Calf-cow ratios and percentage of calves (short-yearlings) were higher following a winter with little snow (< 1.0 m) vs. two others in which snow thickness exceeded 1.0 m (Tables 2 and 5). Rolley and Keith (1980) concluded that *in utero* and/or postpartum losses of Moose calves in Alberta were a response to duration of cold and snow: 76% of the variation in percentage of calves during winter was explained by the number of days during the previous winter with temperatures less than -12°C and snow thicknesses > 25 cm. Pre- and postnatal losses are high among White-tailed Deer in Michigan when does are in poor physical condition following winter (Verme 1963,

1977). Ransom (1967) ascribed the large number of stillbirths and postnatal losses among White-tailed Deer in Manitoba to low winter temperatures that resulted in negative energy balances for long periods despite adequate food supplies.

On the Kenai Peninsula, Alaska, Black Bears killed 34% of 47 radio-collared calf Moose, mostly within their first month (i.e. by late June) (Franzmann et al. 1980). Early postnatal predation by Black Bears may also occur on Dashwoods. According to S. P. Mahoney (personal communication), bears killed 35–40% of 30 radio-collared calves on barrens southeast of Dashwoods during 1982, and 30–50% of 70 others in a cut-over forest of central Newfoundland during 1984–85. Such predation took place within six weeks after birth. We once observed a bear stalking a cow and newborn calf, but suspect that bear densities on our study area were low, as scats and tracks were rarely encountered, and only five adults and three cubs were seen in 33 May–September man-months despite the open landscape. Furthermore, the similarity of mean calf-cow ratios 1–21 days vs. 10–12

months postpartum suggests to us that bear predation was minimal. That tentative conclusion should be easy to test by radio-collaring and monitoring the survival of newborn calves.

Seasonal movements: Our radio-collared Moose were found <10 km from summer home ranges on 92% of 62 winter locations. Mercer and Manuel (1974) also reported short movements (mainly <8 km) by 30 tagged Moose in an adjoining management unit during 1963–64. The longest recorded movement in our study, made by a cow and calf, was 17 km from barrens to extensive forest. Longer, migratory movements have been noted within Moose populations elsewhere (Edwards and Ritcey 1956; Phillips et al. 1973; Hauge and Keith 1981), and apparently occur also on the southernmost section of Dashwoods where the barrens are wholly without wooded cover (W. R. Skinner, personal communication). L. B. K. witnessed such a migration on 3 May 1985 while returning by helicopter from the south coast. Warm weather had softened the deep snow in forested river



FIGURE 3. Moose migrating over open barrens during early May on the Dashwoods Management Unit, southwestern Newfoundland.

TABLE 14. Model of numerical changes in the Dashwoods Moose population over a 1-year period.

February population	2338 (1941 adults and 397 calves) ^a		
1 June population (excluding newborn calves) assuming no adult and 9% calf losses from February to June ^b	2303 (1941 adults and 362 yearlings)		
Number of adults (≥ 1 -year-old) of each sex alive on 1 June given a bull-cow ratio of 27 : 73	622 bulls and 1681 cows		
Number of newborn calves in population on 1 June assuming 40 calves are born/100 cows (Table 8)	672		
Number of Moose living until the following February using 12-month-adult and 9-month-calf survival rates	Bulls	$622 \times 0.47 =$	292
	Cows	$1681 \times 0.86 =$	1446
	Calves	$672 \times 0.76 =$	511
	Total		2249
Annual finite rate of increase (λ) assuming no ingress or egress	2249/2338 = 0.96		

^aCalves constituted 17% of the spring (late March-mid May) population (Table 2).

^bAdult mortality was assumed to be negligible during this period because most (76–100%) deaths apparently occur during the hunting season. Calf survival is the 3-month rate calculated from an annual rate of 0.69 (Table 8).

valleys near the coast and Moose were evidently abandoning these wintering areas. Groups of two to eight Moose were moving northward over the largely snow-free barrens (Figure 3). It was impossible to estimate the total number involved, but for 15 to 20 km Moose were seldom out of sight.

Population model: The hypothetical consequences of our estimates of sex and age composition and age-specific birth and survival rates on Dashwoods were examined in a simple population model (Table 14). None of these demographic estimates had been obtained under the prior assumption of a stationary population. The model began with 2338 individuals in February (as on Dashwoods) and computed the number present one year later. The resulting finite rate of increased (λ) was 0.96 annually, sufficiently close to 1.0 to indicate that our demographic estimates were at least consistent with the apparent stationary nature of the Dashwoods population.

We next asked how the Dashwoods Moose population was sustained given its low reproductive rate and substantial (19%) annual harvest of adults. Overall survival of adults (75% annually) was well within the range determined for stationary or declining populations experiencing harvests of 0–19%, but subject also to wolf predation (Isle Royale, Peterson 1977; northeastern Alberta, Hauge and Keith 1981; interior Alaska, Gasaway et al. 1983). On the other hand, calf survival on Dashwoods (69% annually) was markedly higher than the annual rates of 23–28% reported in the above studies, or the spring-fall rates of 43–50% recorded elsewhere (LeResche 1968; Franzmann et al. 1980). Annual survival

comparable to that among calves on Dashwoods has accompanied population growth in central Alberta (67%) in the absence of predators, and in interior Alaska (54%) following wolf removal (Mytton and Keith 1981; Gasaway et al. 1983).

We conclude from the foregoing analysis that maintenance of the Dashwoods population depends primarily on its high rate of calf survival, a demographic feature of predator-free environments. Calf survival is perhaps also enhanced by a lack of infectious disease and debilitating parasitism (Bergerud and Manuel 1968), and by the presence of snow capable of bearing Moose and thus reducing energy expenditures.

Effect of moose population estimate on calculated rates of harvest, survival and population increase: We used the moose population estimate of 2338 (February 1983) in calculating a mean harvest rate of 19% (Table 6). This harvest rate was then used to estimate survival of both bulls and cows (Table 7), and the latter was subsequently employed to obtain calf survival (Table 8). Lastly, a calculation of annual rate of increase (Table 14) incorporated all the above parameters.

Because confidence limits on the late-winter population of 2338 were broad (Table 1), we examined the sensitivity of calculated harvest, survival and increase rates to potential error in that estimate. Accordingly, these rates were recalculated, setting moose numbers arbitrarily at 1500 and 3000 (Table 15). This major manipulation of population size yielded harvest rates of 26% and 15%, respectively, compared to 19% from a population of

TABLE 15. Effect of error in estimating Dashwoods Moose population on calculated rates of harvest, survival and population increase shown in Tables 6, 7, 8 and 14.

Demographic parameter	Calculated parameter value (%) given total Moose population in February of:		
	1500	2338 ^a	3000
Annual harvest rate	26	19	15
Annual adult survival rate			
Bulls	42	47	47
Cows	92	86	84
Total	67	76	74
Annual calf survival rate	72	69	68
October-April calf survival rate	94	92	92
Annual finite rate of increase	1.00	0.96	0.94

^aThe February 1983 population estimate from Table 1.

2338. The resulting changes in estimated rates of survival and population increase were minor (Table 15), and jeopardized none of the conclusions stated earlier in this paper.

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Literature Cited

- Altmann, M. 1959. Group dynamics in Wyoming Moose during the rutting season. *Journal of Mammalogy* 40: 420-424.
- Ballard, W. B., T. H. Spraker, and K. P. Taylor. 1981. Causes of neonatal Moose calf mortality in south central Alaska. *Journal of Wildlife Management* 45: 335-342.
- Barrett, J. W. 1980. The northeastern region. Pages 25-65 in *Regional silviculture of the United States*. Edited by J. W. Barrett. John Wiley and Sons, New York.
- Bergerud, A. T., and F. Manuel. 1968. Moose damage to Balsam Fir-White Birch forests in central Newfoundland. *Journal of Wildlife Management* 32: 729-746.
- Bergerud, A. T., F. Manuel, and H. Whalen. 1968. The harvest reduction of a Moose population in central Newfoundland. *Journal of Wildlife Management* 32: 722-728.
- Blood, D. A. 1974. Variations in reproduction and productivity of an enclosed herd of Moose (*Alces alces*). *Transactions of the International Congress of Game Biologists* 11: 59-66.
- Bookhout, T. A. 1965. The Snowshoe Hare in Upper Michigan: its biology and feeding coactions with White-tailed Deer. Michigan Department of Conservation Research and Development Report 38. 191 pp.
- Crête, M., R. J. Taylor, and P. A. Jordan. 1981. Optimization of Moose harvest in southwestern Quebec. *Journal of Wildlife Management* 45: 598-611.
- Damman, A. W. H. 1964. Some forest types of central Newfoundland and their relations to environmental factors. *Forest Science Monographs* Number 8. 62 pp.
- Damman, A. W. H. 1967. The forest vegetation of western Newfoundland and site degradation associated with vegetation change. Ph.D. thesis, University of Michigan, Ann Arbor. 319 pp.
- Edwards, R. Y., and R. W. Ritcey. 1956. The migrations of a Moose herd. *Journal of Mammalogy* 37: 486-494.
- Edwards, R. Y., and R. W. Ritcey. 1958. Reproduction in a Moose population. *Journal of Wildlife Management* 22: 261-268.
- Franzmann, A. W., and C. C. Schwartz. 1985. Moose twinning rates: a possible population condition assessment. *Journal of Wildlife Management* 49: 394-396.
- Franzmann, A. W., C. C. Schwartz, and R. O. Peterson. 1980. Moose calf mortality in summer on the Kenai Peninsula, Alaska. *Journal of Wildlife Management* 44: 764-768.
- Gasaway, W. C., and J. W. Coady. 1974. Review of energy requirements and rumen fermentation in Moose and other ruminants. *Le Naturaliste canadien* 101: 227-262.
- Gasaway, W. C., D. B. Harkness, and R. A. Rausch. 1978. Accuracy of Moose age determinations from incisor cementum layers. *Journal of Wildlife Management* 42: 558-563.
- Gasaway, W. C., R. O. Stephenson, J. L. Davis, P. E. K. Shepherd, and O. E. Buris. 1983. Interrelationships of Wolves, prey and man in interior Alaska. *Wildlife Monograph* 84. 50 pp.
- Haagenrud, H. 1979. Sex differential in populations of Norwegian Moose *Alces alces* (L.). *Meddelelser Fra Norsk Viltforskning*, Series 3, Number 6. 19 pp.
- Hauge, T. M., and L. B. Keith. 1981. Dynamics of Moose populations in northeastern Alberta. *Journal of Wildlife Management* 45: 573-597.
- Hines, W. W., and J. C. Lemos. 1979. Reproductive performance by two age-classes of male Roosevelt Elk in southwestern Oregon. Oregon Department of Fish and Wildlife Resources, Wildlife Report Number 8. 54 pp.
- Jessen, R. J. 1978. Statistical survey techniques. John Wiley and Sons, New York. 520 pp.

- Julander, O., W. L. Robinette, and D. A. Jones.** 1961. Relation of summer range condition to mule deer herd productivity. *Journal of Wildlife Management* 25: 54-60.
- LeResche, R. E.** 1968. Spring-fall calf mortality in an Alaska Moose population. *Journal of Wildlife Management* 32: 953-956.
- Lynch, G. M.** 1976. Some long range movements of radio tagged Moose in Alberta. *Proceedings of the North American Moose Conference and Workshop* 12: 220-235.
- Markgren, G.** 1969. Reproduction of Moose in Sweden. *Viltrevy*, Number 6. pp. 127-299.
- Markgren, G.** 1974a. Factors affecting the reproduction of Moose (*Alces alces*) in three different Swedish areas. *Transactions of the International Congress of Game Biologists* 11: 66-70.
- Markgren, G.** 1974b. The question of polygamy at an unbalanced sex ratio in the Moose. Pages 756-758 in *International symposium on the behaviour of ungulates and its relation to management*. Edited by V. Geist and F. Walther. International Union for the Conservation of Nature Publication, New Series, Number 24, Volume 1.
- Mercer, W. E., and F. Manuel.** 1974. Some aspects of Moose management in Newfoundland. *Le Naturaliste canadien* 101: 657-671.
- Mercer, W. E., and M. Strapp.** 1978. Moose management in Newfoundland 1972-77. *Proceedings of the North American Moose Conference and Workshop* 14: 227-246.
- Mitchell, H. B.** 1970. Rapid aerial sexing of antlerless Moose in British Columbia. *Journal of Wildlife Management* 34: 645-646.
- Mohr, C. O.** 1947. Table of equivalent populations of North American small mammals. *American Midland Naturalist* 37: 223-249.
- Mytton, W. R., and L. B. Keith.** 1981. Dynamics of Moose populations near Rochester, Alberta, 1975-78. *Canadian Field-Naturalist* 95: 39-49.
- Oldemeyer, J. L., A. W. Franzmann, A. L. Brundage, P. D. Arneson, and A. Flynn.** 1977. Browse quality and the Kenai Moose population. *Journal of Wildlife Management* 41: 533-542.
- Peek, J. M., R. E. LeResche, and D. R. Stevens.** 1974. Dynamics of Moose aggregations in Alaska, Minnesota, and Montana. *Journal of Mammalogy* 55: 126-137.
- Pehrson, A.** 1981. Winter food consumption and digestibility in caged Mountain Hares. Pages 732-742 in *Proceedings of the World Lagomorph Conference*. Edited by K. Myers and C. D. MacInnes. University of Guelph, Guelph, Ontario.
- Peterson, R. O.** 1977. Wolf ecology and prey relationships on Isle Royale. *National Park Service Scientific Monograph* Number 11. 210 pp.
- Phillips, R. L., W. E. Berg, and D. B. Siniff.** 1973. Moose movement patterns and range use in northwestern Minnesota. *Journal of Wildlife Management* 37: 266-278.
- Pimlott, D. H.** 1953. Newfoundland Moose. *Transactions of the North American Wildlife Conference* 18: 563-581.
- Pimlott, D. H.** 1959a. Reproduction and productivity of Newfoundland Moose. *Journal of Wildlife Management* 23: 381-401.
- Pimlott, D. H.** 1959b. Moose harvest in Newfoundland and Fennoscandian countries. *Transactions of the North American Wildlife Conference* 24: 421-448.
- Ransom, A. B.** 1967. Reproductive biology of White-tailed Deer in Manitoba. *Journal of Wildlife Management* 31: 114-123.
- Robinette, W. J., J. S. Gashwiler, D. A. Jones, and H. S. Crane.** 1955. Fertility of Mule Deer in Utah. *Journal of Wildlife Management* 19: 115-136.
- Robertson, W. M.** 1945. The forests of Newfoundland. *Forestry Chronicle* 21: 11-21.
- Rolley, R. E., and L. B. Keith.** 1980. Moose population dynamics and habitat use at Rochester, Alberta, 1965-1979. *Canadian Field-Naturalist* 94: 9-18.
- Sergeant, D. E., and D. H. Pimlott.** 1959. Age determination in Moose from sectioned incisor teeth. *Journal of Wildlife Management* 23: 315-321.
- Simkin, D. H.** 1965. Reproduction and productivity of Moose in northwestern Ontario. *Journal of Wildlife Management* 29: 740-750.
- Simkin, D. H.** 1974. Reproduction and productivity of Moose. *Le Naturaliste canadien* 101: 517-526.
- Siniff, D. B., and R. O. Skoog.** 1964. Aerial censusing of Caribou using stratified random sampling. *Journal of Wildlife Management* 28: 391-401.
- Snyder, J. D., and R. A. Janke.** 1976. Impact of Moose browsing on boreal-type forests on Isle Royale National Park. *American Midland Naturalist* 95: 79-92.
- Verme, L. J.** 1963. Effect of nutrition on growth of White-tailed Deer fawns. *Transactions of the North American Wildlife and Natural Resources Conference* 28: 431-443.
- Verme, L. J.** 1965. Reproduction studies on penned White-tailed Deer. *Journal of Wildlife Management* 29: 74-79.
- Verme, L. J.** 1967. Influence of experimental diets on White-tailed Deer reproduction. *Transactions of the North American Wildlife and Natural Resources Conference* 32: 405-420.
- Verme, L. J.** 1977. Assessment of natal mortality in Upper Michigan deer. *Journal of Wildlife Management* 41: 700-708.

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Floristic Modification of Low Arctic Tundra by the Arctic Ground Squirrel, *Spermophilus parryii*

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An analysis of Arctic Ground Squirrel (*Spermophilus parryii*) activity and spatial distribution at Eskimo Point, Northwest Territories, indicates that this species significantly alters the composition of the floristic community in Low Arctic tundra. Core areas (areas of greatest activity associated with burrows) were found to be 70% different in floral composition than the surrounding areas where activity was reduced. Lichens were especially reduced by squirrel activity, whereas monocotyledonous and dicotyledonous species increased. Eight species were limited in their distribution to one or the other of the plant communities. Squirrels were found to be associated with elevated habitats especially eskers, which were well drained and composed of sand and/or gravel. The results are discussed in relation to plant-animal interaction and its effect on species diversity and distribution in the ecosystem.

Key Words: Arctic Ground Squirrel, *Spermophilus parryii*, tundra, plant community.

The Arctic Ground Squirrel (*Spermophilus parryii*) is the only species of the family Sciuridae associated with the non-alpine arctic tundra ecosystem in North America (Banfield 1974). Its distribution is limited to the mainland of the continent, in the alpine tundra and open taiga of the west and the open tundra in the east. It is found in well-drained habitats often associated with sand dunes or eskers (Mayer 1953). Recent research by Batzli and Sobaski (1980) and McKendrick et al. (1980) indicates that this species forages on a wide variety of food items of both plant and animal origin and alters the nutrient composition of the soil in areas of high activity. They suggest that both these activities may alter the composition of the floristic community which the squirrels inhabit. Observations of many animal-plant interactions have been documented and these indicate that the distribution and dispersion of some plant species may be strongly correlated with animal activity. This relationship appears to be especially important in the arctic ecosystem (Chew 1974; Batzli and Jung 1980; McKendrick et al. 1980; Mallory and Boots 1983).

This report is a preliminary analysis of the floral composition and spatial distribution of core areas (areas of greatest activity) of Arctic Ground Squirrels found on an esker approximately 3 km south of Eskimo Point, Northwest Territories. It was undertaken to describe the preferred habitat of this species and to establish if squirrels alter the floral composition in areas of high activity.

Materials and Methods

Data were collected during July and August 1981 at Eskimo Point, Northwest Territories (61°06'N; 93°59'W). Core areas of the Arctic Ground Squirrel

were found scattered along a sand and gravel esker, approximately 3 km south of the community. These sites of increased squirrel activity were easily identified from the surrounding terrain because of the numerous burrows, mounded earth, and distinct flora associated with them. Copious quantities of faeces, the frequent observation of squirrels and the occasional squirrel remains also identified these sites as areas of high activity.

An analysis of the floristic communities within and beyond the core areas was initiated using the quadrat method described by Brower and Zar (1977). One-meter quadrats were randomly placed inside (within 3 m of the burrow) and outside (a minimum of 20 m from the nearest burrow) of each of the twelve squirrel core areas studied. Percent cover and frequency of each plant species, litter, and bare ground were recorded, and prominence values ($\text{cover} \times \sqrt{\text{frequency}}$) were calculated (Beals 1960). The coefficient of community (Bray and Curtis 1957) was determined to quantify the similarities and differences between the two floristic communities. In addition, the distances between core areas were measured by triangulation and the total number of burrows and the mean diameters and orientation of each were recorded. Voucher specimens were collected for each species identified (see Acknowledgments), and placed in the herbarium at Laurentian University, Sudbury, Ontario.

Results

All core areas were found on the top of the esker where the humus layer was very thin and the soil was

composed of a fine sand and gravel. Drainage was very good in this region and there was little standing water associated with this habitat, even after heavy rains. The esker was relatively narrow in width (approximately 300 m) and was oriented in an east-west direction, meandering inland perpendicular to the coast. Excavation at two sites indicated that the permafrost was at least 6 m below the surface.

All of the squirrel core areas were oval in shape with their longest axis oriented east and west (east-west diameter 10.5 ± 4.1 m; mean \pm S.D.M.), and their shortest axis oriented north and south (north-south diameter 6.9 ± 2.6 m; mean \pm S.D.M.). Eight of the twelve core areas (66.6%) were on the south-facing edge of the esker and four were on the north edge. The mean number of burrows per core area was 10.8 (range 1 to 42) and the mean nearest-neighbour distance was 52.4 m. An analysis of dispersion was not performed because of the small sample size.

The floristic community associated with core areas was very different from that found beyond them in undisturbed regions (Table 1). The calculated coefficient of community (0.3), indicated that the two communities were only 30 percent similar. In addition, eight species were found to be unique to one or the other of the plant communities. Species found only in the core areas were the lichen *Cetraria sepincola*, moss *Rhytidium rugosum* and vascular plants *Elymus arenaria*, *Epilobium latifolium*, and *Stellaria spp.* Species which were absent from the core areas, but found in the surrounding region were the lichen, *Cladina rangiferina*, and vascular plants, *Rubus chamaemorus* and *Pinguicula vulgaris*. Significant differences in prominence were also observed between the two regions. Lichens represented the most prominent taxon in the undisturbed areas; however, they were replaced by monocots and dicots in the core areas. Major increases in plant litter and bare ground were also associated with the areas of high activity.

Discussion

The data presented support the conclusion that the Arctic Ground Squirrel is very selective in choosing the location of a core area within its home range and territory, and modifies the floristic community associated with these sites. Ecological studies have repeatedly demonstrated that this species is associated with upland sites on the tundra, such as eskers and sand dunes (Mayer 1953; Carl 1971; Banfield 1974; Batzli and Sobaski 1980). In these locations, the permafrost is deep below the soil surface, the soil is relatively easy to burrow into, and there is little water accumulation. Selection of sites with these characteristics would appear to be essential for

survival and reproduction in this species, as it is an obligate hibernator (Bintz 1984) requiring protection from the cold and from seasonal flooding (Carl 1971). The observation that 66.6% of the burrow sites were located on the south-facing side of the esker and that in all cases the long axis of the core areas were oriented at right angles to the drainage system suggests that this orientation is preferred. Carl (1971) observed similar orientation and also noted that such sites were covered with snowdrifts early in the spring. Oosting (1956) suggested that plant productivity may be greater in snow-bank communities. Differences in territorial quality would significantly increase the survival and quality of neonates.

The composition of the flora associated with core areas was substantially different from that found in the surrounding region. The fact that the calculated coefficient of community was 0.30 indicates that the activity of the squirrels caused a 70 percent change in the plant community associated with these localized areas. Lichens, with a few exceptions, disappeared from these sites and were replaced largely by monocotyledonous and dicotyledonous species. Bare ground and litter were also more common on these sites.

Analysis of stomach contents of ground squirrels near Atkasook, Alaska, indicated that although this species forages on a wide variety of plant material, herbaceous dicotyledons formed the most important group, ranging from 25 to 75 percent depending upon the time of year. The plants most favoured had the highest water content and appeared to be the most digestible and nutritious (Batzli and Sobaski 1980). Evergreen shrubs, lichens, and animal matter formed a very small part of the diet and were more often consumed in the spring before new growth emerged. Species with low water content were also avoided.

The data presented here complement the findings of Batzli and Sobaski (1980). Although major increases in dicotyledons occurred on the core areas in this study, most were woody evergreen shrubs. These species are the least palatable; due to chemical antiherbivore defences (Batzli and Jung 1980). In contrast, the major graminoid species associated with core areas were placed only in the moderately palatable category by Batzli and Sobaski (1980); however, they have basal meristem which allows them to tolerate increased levels of grazing. These two vascular plant groups appear to be utilizing slightly different strategies to acquire the benefits of the increased nutrient status (urine, faeces, carcasses, etc.) and the reduced competition present in the core areas. In comparison, the low lichen numbers associated with core areas appeared to be most strongly influenced by disturbance rather than grazing.

TABLE 1. Vegetation analysis of Arctic Ground Squirrel core areas and surrounding terrain on an esker at Eskimo Point, N.W.T. Mean cover % (C), frequency % (F) and prominence values ($P = \text{cover} \times \sqrt{\text{frequency}}$), in 1 m² quadrats indicated.

	Community Type					
	Core Areas (n = 12)			Surrounding Terrain (n = 12)		
	C	F	P	C	F	P
Species						
Lichens						
Spreading Mane Lichen, <i>Coelocaulon divergens</i>	8.73	85.7	8.1	37.56	85.7	34.8
Hooded Shield Lichen, <i>Cetraria cucullata</i>	5.40	100.0	5.4	5.55	92.9	5.3
Furrowed Shield Lichen, <i>Parmelia sulcata</i>	1.08	50.0	0.8	0.05	28.6	*
Snow Lichen, <i>Cetraria nivalis</i>	1.04	57.1	0.8	24.24	92.9	23.4
Roan Mane Lichen, <i>Alectoria ochroleuca</i>	0.59	71.4	0.5	1.11	78.6	1.0
Worm Lichen, <i>Thamnolia vermicularis</i>	0.33	57.1	0.2	1.68	85.7	1.5
Black Shield Lichen, <i>Cetraria nigricans</i>	0.26	35.7	0.2	3.87	42.9	2.5
Brown Shield Lichen, <i>Cetraria sepincola</i>	0.33	7.1	0.1	0.0	0.0	0.0
Ball-Tip Lichen, <i>Sphaerophorus globosus</i>	0.13	71.4	0.1	0.19	85.7	0.2
Pale Shield Lichen, <i>Platismatia glauca</i>	0.12	28.6	0.1	0.20	21.4	0.1
Arctic Finger Lichen, <i>Dactylina arctica</i>	0.09	42.9	0.1	0.09	57.1	0.1
Andrejev's Shield Lichen, <i>Cetraria andrejevii</i>	0.05	35.7	*	2.09	71.4	1.8
Reindeer Lichen, <i>Cladonia Rangiferina</i>	0.0	0.0	0.0	0.02	14.3	*
Total	18.15		16.4	76.65		70.7
Total number of species		12			12	
Bryophytes						
Bristle-pointed Hair Moss, <i>Polytrichum piliferum</i>	1.84	71.4	1.6	1.94	78.6	1.7
Purple Fork Moss, <i>Ceratodon purpureus</i>	1.55	57.1	1.2	4.11	35.7	2.5
Wrinkled-leaved Feather Moss, <i>Rhytidium rugosum</i>	0.16	14.3	0.2	0.0	0.0	0.0
Total	3.55		3.0	6.05		4.2
Total number of species		3			2	
Vascular Plants						
Phyllodoce, <i>Phyllodoce coerulea</i>	15.72	78.6	13.9	6.85	71.4	5.8
Prickly Saxifrage, <i>Saxifraga tricuspidata</i>	8.35	64.3	6.7	0.06	7.1	*
Short-leaved Fescue, <i>Festuca brachyphylla</i>	4.01	78.6	3.6	0.10	21.4	*
Lyme-Grass, <i>Elymus arenaria</i>	4.62	51.4	3.3	0.00	0.0	0.0
Mountain Cranberry, <i>Vaccinium vitis-idaea</i>	2.32	78.6	2.1	2.91	100.0	2.9
Dwarf Birch, <i>Betula glandulosa</i>	2.34	14.3	0.9	0.08	7.1	*
Chickweed, <i>Stellaria sp.</i>	0.74	92.9	0.7	0.00	0.0	0.0
Snow Cinquefoil, <i>Potentilla nivea</i>	0.95	7.1	0.3	0.02	14.3	*
Narrow-leaf Labrador Tea, <i>Ledum decumbens</i>	0.37	28.6	0.2	3.80	71.4	3.2
Bilberry, <i>Vaccinium uliginosum</i>	0.34	21.4	0.2	0.08	28.6	*
Blue Grass, <i>Poa glauca</i>	0.23	35.7	0.1	0.14	14.3	*
Alpine Bear Berry, <i>Arctostaphylos alpina</i>	0.06	14.3	*	0.44	35.7	0.3
Maydelliana Vetch, <i>Oxytropis Maydelliana</i>	0.05	21.4	*	0.01	7.1	*
Broad-leaved Willow Herb, <i>Epilobium latifolium</i>	0.02	7.1	*	0.00	0.0	0.0
Bog Rosemary, <i>Andromeda polifolia</i>	0.01	7.1	*	0.32	28.6	0.2
Cloudberry, <i>Rubus chamaemorus</i>	0.00	0.0	0.0	0.91	35.7	0.5
Common Butterwort, <i>Pinguicula vulgaris</i>	0.00	0.0	0.0	0.05	21.4	*
Total	40.13		32.0	15.77		12.9
Total number of species		15			14	
Litter						
	9.47	100.0	9.5	0.38	100.0	0.4
Bare ground						
	28.71	92.9	27.7	1.16	21.4	0.5
Total	38.18			1.54		

*Prominence values < 0.1

Coefficient of community = 0.3

Lichens are seldom eaten by Arctic Ground Squirrels but are poorly anchored and brittle during dry periods.

Although plant-animal relationships have been studied in a wide variety of mammalian species (Bliss 1975; Batzli and Sobaski 1980; Batzli and Jung 1980; Jenkins 1983; Mallory and Boots 1983; Fraser and Hristienko 1983), most researchers have had difficulty quantifying the changes in plant communities which are species-specific. Our data indicate that the Arctic Ground Squirrel has a significant effect on the distribution of plant species and greatly increases the patchiness and diversity of the floristic community in low arctic ecosystems.

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Literature Cited

- Banfield, A. W. F.** 1974. The mammals of Canada. National Museums of Canada and the University of Toronto Press, Toronto. 438 pp.
- Batzli, G. O., and S. T. Sobaski.** 1980. Distribution, abundance and foraging patterns of the ground squirrels near Atkasook, Alaska. *Arctic Alpine Research* 12: 501-510.
- Batzli, G. O., and H. J. G. Jung.** 1980. Nutritional ecology of microtine rodents: Resource utilization near Atkasook, Alaska. *Arctic Alpine Research* 12: 483-499.
- Beals, E.** 1960. Forest bird communities in the Apostle Islands of Wisconsin. *Wilson Bulletin* 72: 156-181.
- Bintz, G. L.** 1984. Water balance, water stress and the evolution of seasonal torpor in ground-dwelling Sciurids. Pp. 142-165 in *The biology of ground-dwelling squirrels*. Edited by J. O. Murie and G. R. Michener. University of Nebraska Press, London. 459 pp.
- Bliss, L. C.** 1975. Tundra grasslands, herblands and shrublands, and the role of herbivores. *Geoscience and Man* 10: 51-79.
- Bray, J. R., and J. T. Curtis.** 1957. An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs* 27: 325-349.
- Brower, J. E., and J. H. Zar.** 1977. Field and laboratory methods for general ecology. Wm. C. Brown Company Publications, Dubuque, Iowa. 194 pp.
- Carl, E. A.** 1971. Population control in arctic ground squirrels. *Ecology* 52: 395-413.
- Chew, R. M.** 1974. Consumers as regulators of ecosystems: an alternative to energetics. *Ohio Journal of Science* 74: 359-370.
- Fraser, D., and H. Hristienko.** 1983. Effects of moose, *Alces alces*, on aquatic vegetation in Sibley Provincial Park, Ontario. *Canadian Field-Naturalist* 97: 57-61.
- Jenkins, S. H.** 1980. A size-distance relation in food selection by beavers. *Ecology* 61: 740-746.
- Mallory, F. F., and B. N. Boots.** 1983. Spatial distribution of lemming mats in the Canadian High Arctic. *Canadian Journal of Zoology* 61: 99-107.
- Mayer, W. V.** 1953. A preliminary study of the Barrow Ground Squirrel, *Citellus parryi barrowensis*. *Journal of Mammalogy* 31: 334-345.
- McKendrick, J. D., G. O. Batzli, K. R. Everett, and J. C. Swanson.** 1980. Some effects of mammalian herbivores and fertilization on tundra soils and vegetation. *Arctic Alpine Research* 12: 565-578.
- Oosting, J. J.** 1956. The study of plant communities: an introduction to plant ecology. W. H. Freeman and Company, London. 440 pp.

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Summer and Winter Diets of Wolverines, *Gulo gulo*, in Arctic Alaska

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The diet of Wolverines (*Gulo gulo*) in arctic Alaska reflected annual and seasonal changes in food availability. The summer diet was more varied and contained more freshly killed prey items than the winter diet. Arctic Ground Squirrels (*Spermophilus parryi*) were the most frequent item in the summer diet. During winter, Wolverines relied heavily on scavenging to obtain food. The remains of cached Arctic Ground Squirrels were an important part of the winter diet, but remnants of Caribou (*Rangifer tarandus*) carcasses were probably critical to the survival of Wolverines overwintering in the study area. No fresh Caribou carcasses were available during winter 1979-80 and, although Wolverines were able to subsist on Caribou bone and hide during midwinter, nutrition apparently was not adequate for successful reproduction the following spring.

Key Words: Wolverine, *Gulo gulo*, Arctic Ground Squirrel, *Spermophilus parryi*, Caribou, *Rangifer tarandus*, food habits, arctic, Alaska.

The objective of the study was to determine summer and winter food habits of Wolverines (*Gulo gulo*) in an area with no wintering populations of large herbivores. Wolverines are generally believed to eat a variety of foods in summer including carrion, birds' eggs, insects, and berries, but few studies of summer foods of free-ranging Wolverines have been conducted (Krott 1959; Gardner 1985). In all studies reporting on winter food habits, wintering populations of large herbivores have been the most important food item (Pulliainen 1963; Makridin 1964; Haglund 1966; Myrberget et al. 1969; Rausch and Pearson 1972; Myhre and Myrberget 1975; Hornocker and Hash 1981; Gardner 1985). Wolverines have been known to kill prey as large as Moose (*Alces alces*) (Haglund 1974), but most investigators agree that larger mammals in the Wolverine's diet are usually obtained as carrion. All the studies of Wolverine food habits cited above were conducted in forested areas which had some alpine habitat.

Study Area

The study area was located in northwestern Alaska along the upper portions of the Utukok and Kokolik rivers (between 68°30' and 69°N and 160°30' and 162°30'W). The area is treeless, the vegetation characterized by tussock tundra, dry upland meadows, cutbank and floodplain vegetation, and talus and outcrop vegetation (Spetzman 1959). Caribou (*Rangifer tarandus*) are seasonally abundant in the study area from late May until the end of September. Essentially no Caribou have wintered in the area in recent years. Moose occur only

occasionally, rarely in winter. Besides Wolverines, mammalian carnivores include the Grizzly Bear (*Ursus arctos*), Wolf (*Canis lupus*), Red Fox (*Vulpes vulpes*), Arctic Fox (*Alopex lagopus*), Short-tailed Weasel (*Mustela erminea*), and Least Weasel (*Mustela nivalis*). Smaller mammals that occur in the study area include the Hoary Marmot (*Marmota caligata*), Arctic Ground Squirrel (*Spermophilus parryi*), lemmings (*Lemmus sibiricus* and *Dicrostonyx groenlandicus*), voles (*Microtus oeconomus*, *Microtus miurus*, *Clethrionomys rutilus*), and shrews (*Sorex* spp.). Depending on habitat type, from 20 to 50 species of birds have been reported to breed in areas adjacent to the study area (Irving and Paneak 1954; Kessel and Cade 1958; Maher 1959).

Methods

Food habits during summer (May-August) were determined primarily through direct observation of adult radio-collared Wolverines from aircraft and occasionally from the ground. If a Wolverine was observed capturing, carrying, caching, or eating a food item, an attempt was made to identify the item either by visual identification or indirectly by the method of capture, such as mousing. Additional information on summer food habits was gathered at sites where a female left her kits while she hunted (rendezvous sites). Food remnants were noted and scats were collected at these sites.

Scat analysis was the main method of determining winter (September-April) food habits. Scats were collected along Wolverine trails from September

through March and from natal den sites used in March and April. Scats were dried, broken apart, separated into categories, and each category weighed. The categories were Caribou, Red Fox, Arctic Ground Squirrel, other small mammals (as a group), birds (including feathers and eggshells), and soil. Soil was a major component of some scats; these were broken into sieves and washed to separate food remains from soil.

Scats collected along winter trails were analyzed by three time periods: early winter (September–November), midwinter (December–February), and late winter (March–April). Food categories were expressed as a frequency of occurrence and as a proportion of the total weight of all food remains (percentage dry weight).

Scats collected at dens or rendezvous sites were analyzed as a group because they were deposited in large piles and the date of deposition was unknown. Therefore, only percentage dry weight over the entire winter was calculated for these scats. The percentage dry weight data were compared among collection sites and among years.

Frequency of occurrence of soil in scats was determined by dividing the number of scats containing soil by the total number of scats collected along winter trails for each winter period. The percentage dry weight was determined by dividing the total weight of the soil by the total weight of all scat material collected during each winter period and at the rendezvous sites.

Results and Discussion

Analysis of Food Habits

Wolverines were observed capturing, carrying, caching, or eating 48 food items during 362 five-minute observation periods in summer (Table 1). The first five minutes of flight time over the Wolverines was considered a sampling unit. There was only one food item per sampling unit, except for one case when

a Wolverine captured two Arctic Ground Squirrels within the same five-minute period. Food items were not identified on 15 occasions and were visually identified or determined by the method of capture on 33 occasions. Of the identified food items, 58% were Arctic Ground Squirrels, 18% were other small mammals, and 18% were Caribou.

These results and other observations suggest that diet was more varied in May and June than in August. Evidence found at a rendezvous site used by an adult female Wolverine (F7) and her two kits on 2 June 1979 indicated that the Wolverines had been eating Arctic Ground Squirrels, Willow Ptarmigan (*Lagopus lagopus*) eggs, and small mammals. During 149 minutes of hunting behavior on 4 June 1979, F7 made 34 searches for food items in tussock tundra. She pounced on seven occasions, probably for small mammals but possibly for ptarmigan chicks, and was successful at least twice. In addition, she captured and cached an adult ptarmigan, found or caught a squirrel, and on two occasions appeared to find and eat eggs.

In late summer, the radio-collared Wolverines increased their time spent in hunting squirrels. The number of five-minute sampling units in which squirrel hunting was observed (Table 1) was significantly higher in August than in the other summer months (May–July) combined ($\chi^2 = 5.11$, $0.025 > P > 0.01$, $df = 1$), and Wolverine hunting and feeding activity involved squirrels much more frequently than all other food items combined ($\chi^2 = 12.27$, $P < 0.001$, $df = 1$).

For winter food habits analysis, 82 scats were collected along Wolverine trails, most during November, February, and March 1979–80. Caribou and Arctic Ground Squirrels remains occurred in 37% and 40% of the scats, respectively, and made up 35% and 32% of the total scat weight, respectively. The remains of lemmings, voles, and shrews as a group occurred in 30% of the scats but made up only 6% of

TABLE 1. Number of times feeding behavior (capturing, carrying, caching, or eating food) by Wolverines was observed from the air during 362 five-minute observation periods during summer in northwestern Alaska, 1978–1981.

Food Item	May	June	July	August	Total
Caribou	1	4	1		6
Marmot		1			1
Arctic Ground Squirrels	3	1	4	11	19
Other Small Mammals	3	3			6
Willow Ptarmigan		1			1
Total Identified	7	10	5	11	33
Total Not Identified	3	2	1	9	15
Grand Total	10	12	6	20	48
5-min Observation Periods	95	122	50	95	362

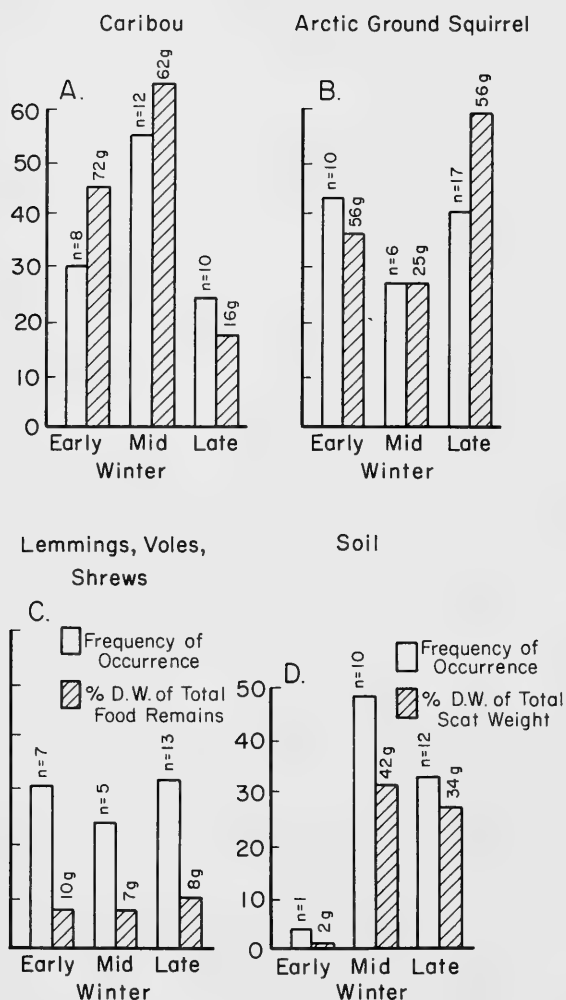


FIGURE 1. Frequency of occurrence and percentage dry weight (D.W.) of the three most common food categories and of soil ingested by Wolverines in arctic Alaska during three periods in winter.

the total scat weight. No attempt was made to sort lemming, vole, and shrew remains into separate categories or to identify them by species because of their low prevalence in the scats. The remains of birds and/or eggs occurred in only 11% of the scats and made up only 3% of the total scat weight. There were 13 g (3%) of unidentified food remains and 78 g (18%) of soil. Caribou remains were more frequent in scats from midwinter than from early or later winter ($\chi^2 = 6.26$, $0.02 < P < 0.05$, $df = 2$), but the frequency of occurrence of squirrel and other small mammal

remains showed no significant change during winter (Figure 1).

The percentage dry weight of Caribou and squirrel remains showed seasonal changes that corresponded to the changes in frequency of occurrence (Figure 1). This correspondence resulted from the fact that when the remains of Caribou or squirrels occurred in a scat, each made up 80–100% of the total weight of all food remains in the scat in 80% and 85% of the scats, respectively. When other small mammal remains occurred in the scats, they made up 80–100% of the total food remains in the scat only 52% of the time. Note that percentage dry weight for Caribou is higher than frequency of occurrence in early winter and in midwinter but not in late winter; percentage dry weight for Arctic Ground Squirrels is higher than frequency of occurrence only in late winter (Figure 1). In early winter and in midwinter, 62% of the heaviest scats (i.e., weighing more than the average for that period) contained Caribou and most contained 80–100% Caribou. In late winter, 70% of the heaviest scats contained squirrels. None of the heaviest scats in any period contained the remains of other small mammals as the primary food category. These results suggest that the importance of Caribou in the Wolverine diet declined in late winter, whereas the importance of squirrel increased.

The frequency of occurrence of soil in the scats changed significantly during winter ($\chi^2 = 9.94$, $0.001 < P < 0.005$, $df = 1$). Soil occurred more frequently and in greater proportions in mid- and late winter than in early winter (Figure 1). Most of the soil was associated with scats which contained squirrel remains. In early winter, 10% of the scats with squirrel remains contained soil, in midwinter, 83%, and in late winter, 50%. No scats with Caribou remains contained soil in early winter, 33% contained soil in midwinter, and 20% contained soil in late winter.

Of 23 scats containing soil, 11 contained squirrel but no Caribou; only three contained Caribou but no squirrel. Four scats were made up entirely of soil. The remaining five scats contained a combination of food remains.

If it can be assumed that soil is passed through the intestinal tract at the same rate as Caribou and squirrel remains, then it appears that soil is primarily ingested while Wolverines are eating squirrels and that soil is more often associated with squirrels eaten in midwinter than in early or late winter. This is further supported by the proportionally lower percentage dry weight in relation to frequency of occurrence for soil in midwinter (Figure 1). Because squirrels occur less frequently in scats in midwinter, soil by weight should be proportionally less.

I believe the relationship of soil and squirrel remains is due to the use of cached squirrels, particularly in midwinter. Although fewer squirrels may be ingested in midwinter, those that are eaten are almost certainly cached squirrels. While we were radio-tracking Wolverines in the winter, it was common to find a Wolverine partially or wholly hidden in a freshly excavated hole in the snow with soil and vegetation spread around on the surface of the snow. In one instance, an adult male Wolverine was half submerged in the snow, his tail and haunches protruding above the surface. At my approach, the Wolverine ran from the hole where he had been feeding on a squirrel frozen into the soil. Half of the squirrel's body was still in the hole. The carcass was shredded and thawed where the Wolverine had been gnawing. It appeared as though the sides of the hole had also been gnawed, suggesting that this is how much of the soil in the scats is ingested.

Some of the squirrels in the winter diet may be dug out of hibernation while alive or after dying due to starvation or exposure. On 24 March 1980 I found a hole which a Wolverine had excavated through 15 cm of snow and 25 cm of soil in upland tundra with a slope of less than 10°. At the bottom of the hole was an enlarged cavity with squirrel hairs in it. The symmetrically round hole leading to the cavity was 17 cm in diameter.

Some information on winter food habits was gained from examining areas where Wolverines had been digging along their travel routes. In approximately 80 km of tracking Wolverines in winter, 186 "digs" were found that could be attributed solely to Wolverines. Of these, 110 had been dug into earth with no indication of whether a food item had been present. Fourteen were snow tunnels which were too deep for the contents to be determined. Six "digs" had flecks of blood, indicating that the food items were fresh kills, probably voles or lemmings. Sixteen "digs" had squirrel remains (usually just a few hairs), 16 had Caribou bone fragments, 5 had ptarmigan feathers, 1 had a whole shrew, 1 had a dried, mud-caked duck carcass, and 3 had eggshells. The remainder of the "digs" had been dug into snow with no evidence of food remains.

Scats collected at natal den sites represent food consumed primarily in March and April (late winter). Of 5864 g of scats collected at natal den sites (representing at least 300 individual scats based on the average weight of scats collected along Wolverine trails), Caribou and squirrels accounted for 92% of the dry weight of food items in the scats. The percentage of Caribou and squirrels differed among years and among individuals (Figure 2). Scats collected at what was believed to be the location of F7's 1978 den

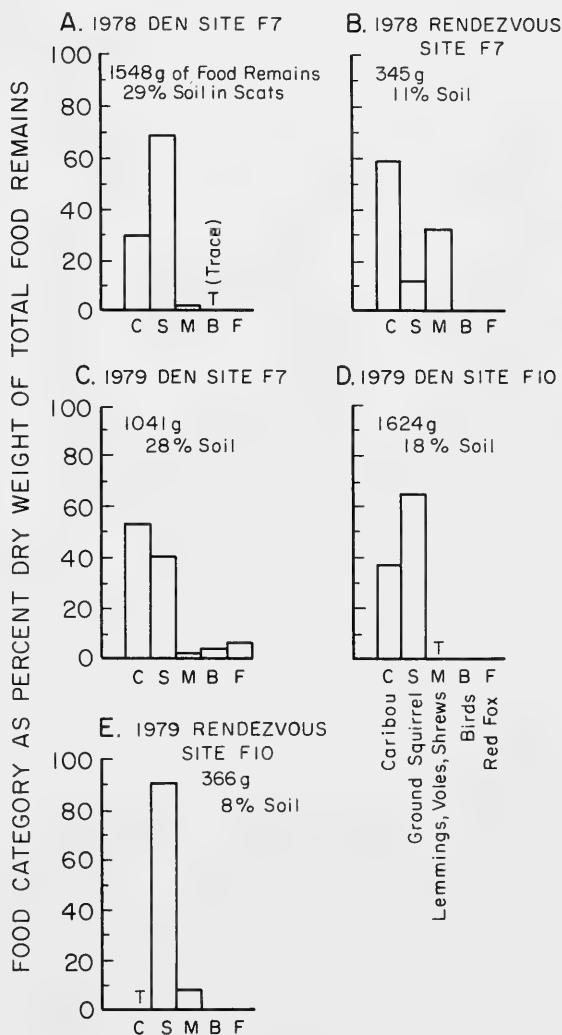


FIGURE 2. Percentage dry weight of food remains collected at Wolverine natal den sites and rendezvous sites in arctic Alaska and the percentage of the total scat weight made up of soil.

contained 69% squirrel and 29% Caribou remains by percentage dry weight (Figure 2). From scats collected at F7's 1979 den, the percentage of squirrel remains was only 40% and Caribou was 52%. Scats were not collected from F7's 1978 den until summer 1979 when the den site was discovered by a field assistant on 11 June 1979. The den site was recognizable by the piles of scats and broken, matted vegetation where the tunnels and beds had been located. F7 and her 4-month-old kit had been captured in June 1978 in a

nearby drainage at a rendezvous site. The high percentage of squirrel remains in the scats collected at the 1978 den could have been due to the fact that the den site itself had been used periodically as a rendezvous site during May and June 1978. F7's 1979 den was used only until 29 April, so the scats from this den represent food eaten in March and April 1979, which is the denning period.

Scats collected at F10's 1979 den contained 63% squirrel remains and only 37% Caribou remains (Figure 2). A relatively high percentage of squirrel remains by weight was found at the den, although F10 was known to have abandoned the den in late April 1979. The soil associated with food remains from this den was 10% less than soil in scats collected at F7's 1978 and 1979 dens. This difference in soil content suggests that more of the squirrel remains at F10's den were from fresh kills and that fresh Arctic Ground Squirrels may have been more available to F10 than to F7 in late winter. F10's home range contained more suitable squirrel habitat, with higher terrain and numerous south-facing slopes.

Scats collected at rendezvous sites were deposited primarily during May and June. At a rendezvous site used from 12 to 20 May 1979 by female Wolverine F10 and her two kits, a much higher percentage of squirrel remains (89% of the dry weight of all food remains) was found than at any other scat collection site (Figure 2). Soil in the scats accounted for only 8% of the total scat weight.

Scats from a rendezvous site used by F7 and one kit were collected on 29 June 1978, at which time the two Wolverines were still using the site. The date of the initial establishment of the site is unknown. Most of the scats probably represent food items eaten in May and June. The skeleton of a Caribou was found about 600 m from the site. It was probably the remains of a Caribou which had died during the spring migration in May or June. As might be expected, Caribou ranked high (58%) among food remains in the scats from this site (Figure 2). Lemming, vole, and shrew remains were high (23% by weight) relative to the other scat collections analyzed.

Seasonal Changes in Food Availability

Wolverines were opportunistic in their food habits, responding to temporarily abundant or easily procurable food. Their diet reflected annual and seasonal changes in food availability. Late winter marked the beginning of a plentiful and varied food supply for Wolverines in the study area. Arctic Ground Squirrels emerged from hibernation from late March to mid-May. The earliest date of emergence observed during the study was 9 March 1980, although emerging squirrels were usually not a common sight until late March or early April. Immediately following emergence from hibernation,

squirrels established breeding territories and were aggressive towards each other. Green (1977) reported that agonistic interactions peak 2 to 3 weeks after the first squirrels emerge and that squirrels are particularly vulnerable to predation at this time. It is therefore not surprising that a relatively high proportion of squirrel remains occurred in scats collected at the natal den sites and along tracking routes in March and April. Wolverines were still eating cached squirrels in March; however, the decrease in the proportion of soil in scats from January and February to March indicates that the Wolverines began to consume freshly killed squirrels in March.

Other food items began to increase in the diet in May. Lemming, vole, and shrew remains in scats and observations of Wolverines capturing or eating these small mammals were highest in May and June, a time when small rodents become vulnerable to predation as their nest sites and runways are exposed by melting snow. Birds and eggs were more available in June, the peak of the nesting season. The spring migration of Caribou through the study area usually began in late May, and calving peaked between 2 and 10 June. Adult Caribou dying during migration or calves dying at birth and shortly afterward provided carrion for Wolverines at this time of year.

As the summer progressed, squirrels made up an increasing proportion of the diet as other food items became less available and squirrels again became vulnerable to predation due to dispersal. Dispersal peaked in August. At this time, squirrels were the most important food item in the Wolverine's diet.

Berries and insects, which Wolverines have been observed eating in summer in other studies (Krott 1959), did not occur in appreciable amounts in the study area and no evidence of Wolverines' using these foods was documented.

By early October, the availability of food for Wolverines began to decline. Sightings and fresh sign of Caribou and squirrels were absent by the end of November. The number of squirrels in the diet was reduced by midwinter and most of those that were eaten were probably obtained from caches made in summer and fall.

Caribou remains were important to Wolverines in the study area during midwinter 1979-80. Caribou remains eaten by Wolverines that winter were mostly the remnants of carcasses buried by scavengers or bone and hide lying on the tundra. Several winter scats (10%) were found that consisted entirely of Caribou bone fragments bound by a white powdery matrix. Sometimes the only excrements found along winter trails of Wolverines were small amounts of chalky liquid. Kruuk (1972) analyzed the fine white powder in Spotted Hyena (*Crocuta crocuta*) droppings and found that it consisted of

$\text{Ca}_3(\text{PO}_4)_2 \cdot 1.5\text{Ca}(\text{OH})_2$, which is the formula for inorganic matter in bone. He concluded that bone is digested by the hyena and only the inorganic matter is excreted. Bone may contain up to 40% organic matter, mostly collagen. Kruuk postulated that hyenas are able to use all the organic matter present in bones, not just the marrow. Van Zyll de Jong (1975) suggested that Wolverines are also morphologically and behaviorally adapted to a scavenging lifestyle.

Caribou composed a major portion of the Wolverine's winter diet despite the fact that Caribou generally do not occur in the study area during most of the winter. In this area, where Caribou occur in large numbers only during the summer, Wolverines were able to subsist during winter 1979–80 on Caribou remains comprising mainly bone and hide, occasionally supplementing their diet with squirrels gnawed from the frozen tundra. The Wolverine's ability to survive the most severe time of the year on such a meager diet attests to its efficiency as a scavenger.

There is evidence that such a restricted diet in winter 1979–80, however, may have had some effect on Wolverine reproduction in the study area. One adult female Wolverine (F19) was considered to be malnourished that winter, perhaps even on the verge of starvation, based on her poor physical condition and the unusual number of visits she made to baited live traps (Magoun 1985). In addition, spring 1980 was the only spring in four years (1978–81) in which one adult female Wolverine (F7) failed to raise young. Three other radio-collared adult females also failed to raise young that summer. Although the Wolverines were able to survive the winter, their reproductive potential may have been limited by food shortages (Magoun 1985). Furthermore, the movements of an adult female (F24) in winter 1981–82 indicated that Wolverines will leave an established home range when food is scarce (Magoun 1985).

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Literature Cited

- Gardner, C. L.** 1985. The ecology of wolverines in southcentral Alaska. M.Sc. thesis, University of Alaska, Fairbanks, Alaska. 82 pp.
- Green, J. E.** 1977. Population regulation and annual cycles of activity and dispersal in the arctic ground squirrel. M.Sc. thesis, University of British Columbia, Vancouver, B.C. 193 pp.
- Haglund, B.** 1974. Moose relations with predators in Sweden, with special reference to bear and wolverine. *Le Naturaliste canadien* 101: 457–466.
- Hornocker, M. G., and H. S. Hash.** 1981. Ecology of the wolverine in northwestern Montana. *Canadian Journal of Zoology* 59: 1286–1301.
- Irving, L., and S. Paneak.** 1954. Biological reconnaissance along the Ahlasuruk River east of Howard Pass, Brooks Range, Alaska, with notes on the avifauna. *Journal of the Washington Academy of Science* 44: 201–211.
- Kessel, B., and T. J. Cade.** 1958. Birds of the Colville River, northern Alaska. Biological Paper No. 2, University of Alaska, Fairbanks, Alaska. 83 pp.
- Krott, P.** 1959. Der Vielfrass (*Gulo gulo* L. 1758). *Monographien der Wildsäugetiere* 13: 1–159.
- Kruuk, H.** 1972. The spotted hyena. University of Chicago Press, Chicago, Illinois. 335 pp.
- Magoun, A. J.** 1985. Population characteristics, ecology, and management of wolverines in northwestern Alaska. Ph.D. thesis, University of Alaska, Fairbanks, Alaska. 197 pp.
- Maher, W. J.** 1959. Habitat distribution of birds breeding along the upper Kaolak River, northern Alaska. *The Condor* 61: 351–368.
- Makridin, V. P.** 1964. The distribution and biology of the wolverine in the Far North. *Zoologicheskii Zhurnal* 11: 1688–1692.
- Myhre, R., and S. Myrberget.** 1975. Diet of wolverine (*Gulo gulo*) in Norway. *Journal of Mammalogy* 56: 752–757.
- Myrberget, S., B. Groven, and R. Myhre.** 1969. Tracking wolverine, *Gulo gulo*, in the Jotunheim Mountains, south Norway, 1965–68. *Fauna* 22: 237–252.
- Pulliainen, E.** 1963. Occurrence and habits of the wolverine (*Gulo gulo*) in Finland [Finnish with English summary]. *Suomen Riista* 16: 109–119.
- Rausch, R. A., and A. M. Pearson.** 1972. Notes on the wolverine in Alaska and the Yukon Territory. *Journal of Wildlife Management* 36: 249–268.
- Spetzman, L. A.** 1959. Vegetation of the arctic slope of Alaska. U.S. Geological Survey Professional Paper 302-B, Washington, D.C. 58 pp.
- van Zyll de Jong, C. G.** 1975. The distribution and abundance of the Wolverine (*Gulo gulo*) in Canada. *Canadian Field-Naturalist* 89: 431–437.

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Home Range and Habitat Utilization of Breeding Male Merlins, *Falco columbarius*, in Southeastern Montana

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Home range size and habitat utilization of three breeding male Richardson's Merlins (*Falco columbarius richardsonii*) in southeastern Montana were studied using radio telemetry. Home ranges of these birds encompassed 13, 23, and 28 km². Each bird traveled up to 9 km from its nest. Each home range encompassed five habitats; sagebrush/grassland, riparian, and Ponderosa Pine (*Pinus ponderosa*) communities were used significantly ($p \leq 0.05$) more, and grasslands and agricultural fields less ($p \leq 0.05$), than expected, based on the proportions in the combined home ranges. Four sites regularly used by hunting male Merlins indicated preferences for patchy shrub/grasslands as hunting habitats.

Key Words: Merlin, *Falco columbarius*, home range, habitat, southeastern Montana.

Richardson's Merlin (*Falco columbarius richardsonii*) is an inhabitant of sparsely treed grasslands in the northern Great Plains. Breeding pairs in Canada nest in small groves of deciduous trees along rivers (Bent 1938) and shelterbelts adjacent to grasslands (Hodson 1976). In the western United States, Richardson's Merlins nest in deciduous riparian communities (Call 1978) and in coniferous stands in close proximity to grasslands (Ellis 1976; Becker 1984).

Previous food studies in these areas suggest that Richardson's Merlins hunt in grassland habitats (Bent 1938; Fox 1964; Hodson 1976); however, detailed information on habitat utilization and home ranges of these birds is lacking in the literature. The objectives of this study were to determine the size of home ranges of male Merlins and to identify preferred hunting habitats. Males were selected for study because they do most of the hunting for the breeding pair and nestlings.

Study Area

The 39 448-ha study area in southeastern Montana consisted largely of sagebrush/grassland shrub-steppe and agricultural fields interspersed with buttes and rolling hills dominated by stands of Ponderosa Pine (*Pinus ponderosa*). Maximum elevation is 1282 m above sea level. The climate is characterized by hot summers, cold winters, and a semi-arid moisture regime. Annual precipitation averages 39 cm, of which 70% falls from May through

September. Monthly mean temperatures during the Merlin breeding season range from -8°C in March to 33°C in July.

Methods

Adult male Merlins were captured near their nest sites in late May and early June of 1980. To minimize disturbance of breeding adults near their nests, capture was attempted only after young had hatched. A dho-gazza trapping device was modified from that described by Beebe and Webster (1964), and a permanently crippled Great Horned Owl (*Bubo virginianus*) was used to lure the Merlins into mist nets. After capture, the Merlins were restrained in a stocking while the transmitters were being attached.

Each of the three male Merlins captured was fitted with an SM-1 transmitter manufactured by the AVM Instrument Company¹. The transmitter package weighed approximately 7 g, or approximately 4% of the bird's weight. It was attached ventrally to the proximal end of the shaft of a central tail feather by two strands of monofilament embedded in the dental acrylic covering of the transmitter package. Antennas

¹The use of the SM-1 transmitter (AVM Instrument Company) name is for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the U. S. Department of Agriculture and the U.S. Department of Interior to the exclusion of others that may be suitable.

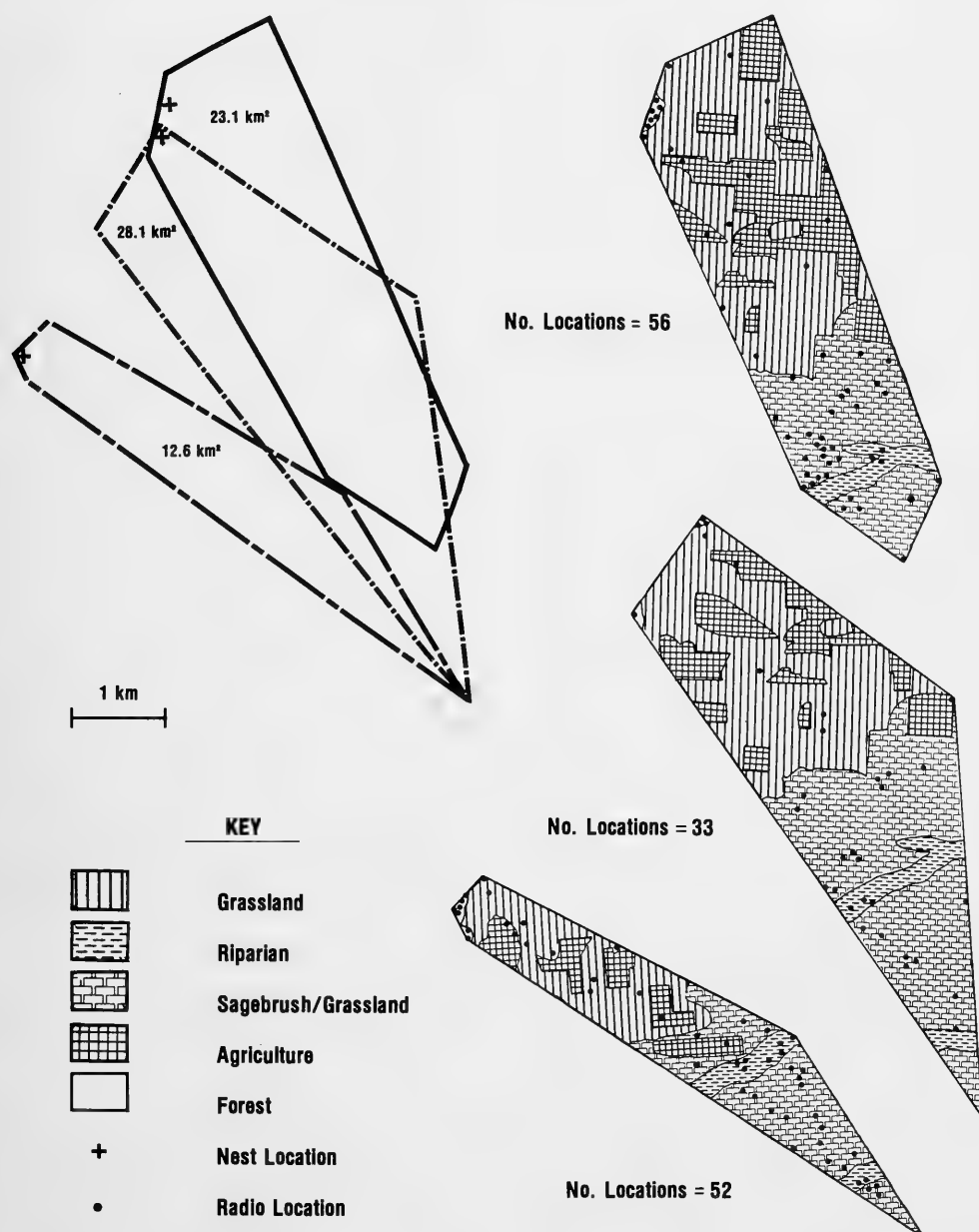


FIGURE 1. Home ranges, habitat types, and radio locations of three breeding male Richardson's Merlins in southeastern Montana.

on each transmitter were approximately 14 cm in length. Two additional monofilament strands stabilized the antenna on the feather at intervals of approximately 4 and 8 cm from the transmitter package. All monofilament strands were secured by two square knots and epoxy glue.

Movements of the three male Merlins fitted with transmitters were simultaneously monitored for five days (eight consecutive hours) and during portions (a minimum of four consecutive hours) of 12 subsequent days during June and July of 1980. One fixed monitoring station and a mobile unit were used to

track the birds. Triangulation was necessary due to the extreme difficulty of visually locating the birds. Locations of each bird were recorded at 15-minute intervals, and time, location of the investigator, and azimuth were recorded for each monitoring effort. Bearings were later plotted on USGS topographic maps (scale 67.4 mm = 1.61 km). Home range size of each male Merlin was calculated by use of a planimeter and delineated by the minimum home range method (Mohr 1947).

Habitats within each male Merlin's home range were delineated on the basis of physiognomic features and mapped. Area and percentage of each habitat were calculated within each home range. Pooled habitat use patterns for radio-tagged Merlins were evaluated with contingency tables, and numbers of observations in the various habitats were compared to expected numbers, based on proportional availability, by chi-square analysis (Neu et al. 1974).

Vegetation characteristics were sampled at four sites where at least 12 locations of one or more of the male Merlins were clustered. Percent plant canopy cover was estimated by species in 150, 0.1-m² quadrats spaced at 1-m intervals along three, 50-m transects on each site (Daubenmire 1959). Maximum vegetation height within each quadrat was also recorded. Shrub densities (numbers of individual stems of each species present) were sampled in 90-milacre (2.1-m²) quadrats spaced at 2-m intervals on alternate sides of the three, 50-m transects on each site. Beetle (1970) was used as the authority for common and scientific names.

Results

Home ranges of the three male Merlins ranged from 13 to 28 km² and were elongated in shape (Figure 1). The home range of each bird overlapped that of at least one of the other male Merlins. The nest site of

one of the Merlins was also located within the home range of another male whose nest was located in an adjacent drainage. Maximum distances traveled from nests were 8 to 9 km.

Five physiognomic habitats were delineated within the home ranges of the three male Merlins. The sagebrush/grassland habitat was characterized by varying densities of Big Sagebrush (*Artemisia tridentata*) and mixed grasses such as Western Wheatgrass (*Agropyron smithii*), Blue Grama (*Bouteloua gracilis*), Buffalograss (*Buchloe dactyloides*), Prairie Junegrass (*Koeleria cristata*), and a variety of other species. Shrubs such as Silver Sagebrush (*A. cana*), Woods Rose (*Rosa woodsii*), and Western Snowberry (*Symphoricarpos occidentalis*), and grasses such as Western Wheatgrass and bluegrass (*Poa* spp.) characterized the vegetation along the ephemeral stream in the riparian habitat. The grassland habitat occurred on lowlands surrounding the buttes, and was dominated by Western Wheatgrass, Blue Grama, Prairie Junegrass, Needle and thread (*Stipa comata*), and bluegrass; shrub cover in this habitat was limited to stands of Western Snowberry in mesic drainages and scattered, small stands of Silver and Big sagebrush. The Ponderosa Pine habitat dominated the sideslopes of the buttes, and consisted of Ponderosa Pine of mixed ages and densities. Grain, fallow, and hayfields collectively constituted the agriculture habitat.

Sagebrush/grassland, riparian, and Ponderosa Pine habitats were used significantly ($p \leq 0.05$) more by hunting Merlins than expected, based on proportionate availability (Table 1). Grassland and agriculture habitats were utilized significantly less ($p \leq 0.05$) than expected.

Big Sagebrush and Blue Grama were dominant plant species at two sites (sites 2 and 3) where the hunting male Merlins were most frequently observed

TABLE 1. Combined radio locations of three breeding male Richardson's Merlins in five habitats in southeastern Montana.

Habitat	Area (ha)	Proportion of total	Observed number of locations	Expected number of locations	Habitat selection ¹	Proportion observed in each habitat type and 95% confidence interval
Sagebrush	2770	43.4%	76	61	+	0.54 ± 0.11
Grassland	2169	34.0%	22	48	-	0.16 ± 0.08
Agriculture	1182	18.5%	12	26	-	0.08 ± 0.06
Riparian	209	3.3%	14	5	+	0.10 ± 0.07
Pine	51	0.8%	17	1	+	0.12 ± 0.07
Total	6381		141	141		

¹+denotes significantly greater ($p < 0.05$) use than expected.

-denotes significantly less ($p \leq 0.05$) use than expected.

TABLE 2. Percent bare ground, litter cover, and plant canopy cover of major plant species on four sites where male Richardson's Merlins were frequently observed hunting in southeastern Montana.

Cover Type	Site number			
	1	2	3	4
BARE GROUND	42.5	18.9	18.4	9.3
LITTER	8.9	16.4	19.8	29.6
SHRUBS				
Silver Sagebrush, <i>Artemisia cana</i>				10.4
Fringed Sagebrush, <i>A. frigida</i>	0.6	0.1	1.1	
Big Sagebrush, <i>A. tridentata</i>	19.3	11.7	7.4	0.2
Plains Pricklypear, <i>Opuntia polyacantha</i>	1.1	0.7	0.6	
Woods Rose, <i>Rosa woodsii</i>				1.2
Western Snowberry, <i>Symphoricarpos occidentalis</i>				16.3
OTHER SHRUBS ¹	1.0	1.0	1.3	
GRASSES				
Western Wheatgrass, <i>Agropyron smithii</i>	6.4	2.6	5.3	16.1
Blue Grama, <i>Bouteloua gracilis</i>	2.1	13.7	8.2	
Buffalograss, <i>Buchloe dactyloides</i>	1.3		2.0	
Sandberg Bluegrass, <i>Poa secunda</i>	0.5			2.3
Other grasses ²	1.0	1.1	1.3	
FORBS				
Common Yarrow, <i>Achillea millefolium</i>	1.0		0.5	1.0
Other forbs ³			1.0	1.9
OTHER				
Lichen, <i>Parmelia chlorochrae</i>	1.9	2.2	2.5	
Club Moss, <i>Selaginella densa</i>	5.3	26.4	10.6	
Algae	2.6	2.5	0.8	

¹Gardner Saltbush (*Atriplex gardneri*), Broom Snakeweed (*Gutierrezia sarothrae*).

²Tumblegrass (*Schedonnardus paniculatus*), Needle and thread (*Stipa comata*).

³Small-leaf Pussytos (*Antennaria parvifolia*), thistle (*Cirsium* sp.), Scarlet Gaura (*Gaura coccinea*), Silky Crazyweed (*Oxytropis sericea*), Fuzzytongue Penstemon (*Penstemon eriantherus*), Scurfpea (*Psoralea* sp.), Field Pennycress (*Thlaspi arvense*), Hoods Phlox (*Phlox hoodii*).

(Table 2). Site 3 was dominated by Big Sagebrush and Western Wheatgrass. Each of these three sites were in the sagebrush/grassland habitat. Site 4 was in the riparian habitat, and was dominated by Western Snowberry and Western Wheatgrass.

Shrub densities in the three sagebrush/grassland sites were variable, ranging from 7530 to 14740 stems/ha of Big Sagebrush and Gardner Saltbush (*Atriplex gardneri*) (Table 3). The riparian site had a total shrub density of 43350 stems/ha. Average maximum vegetation height was also variable, averaging 16.6 cm on the three sagebrush/grassland sites, and 44 cm on the riparian site.

Discussion

Few comparative data on home range sizes or foraging distances of breeding Merlins are available. Hodson (1976) concluded from behavioral observations that breeding Merlins in Alberta hunted up to 1.6 km from their nesting sites. The home ranges of

the Montana Merlins and maximum distances they traveled from their nests were considerably larger. Richardson's Merlins have longer wings and tails and lighter wing-loading in comparison with other subspecies of Merlins inhabiting forested habitats. These physical differences may be adaptations that allow this subspecies to range over large areas (Temple 1972). Other factors involved in these differences may have included differences in habitats within home ranges, terrain, prey availability and abundance, or some combination of these factors.

Results of this study indicated a high degree of use of sagebrush/grassland habitats by hunting male Merlins during June and July. A study of food habits of this population of Merlins indicated that Horned Larks (*Eremophila alpestris*), Lark Buntings (*Calamospiza melanocorys*), and Vesper Sparrows (*Pooecetes gramineus*) constituted 27%, 18%, and 13% of 427 food items, respectively (Becker 1984). Merlin use of sagebrush/grassland may have been a

TABLE 3. Shrub densities (stems/ha) at four sites where hunting male Richardson's Merlins were frequently observed in southeastern Montana.

Species	Shrub densities (stems/ha)			
	Site number			
	1	2	3	4
Big Sagebrush	14 740	7 110	4 470	130
Western Snowberry	—	—	—	35 590
Silver Sagebrush	—	—	—	5 540
Woods Rose	—	—	—	2 090
Gardner Saltbush	—	420	20	—
Totals	14 740	7 530	4 490	43 350

direct result of relatively high densities of Horned Larks and Vesper Sparrows drawn to food, cover, and elevated perches provided by Big Sagebrush interspersed with grassland.

Male Merlins were observed less often in grasslands than expected, based on availability of this habitat. In contrast, food habits of breeding Merlins in southeastern Montana indicated that birds typically associated with open grassland habitat were heavily preyed upon (Becker 1984). Similar results have been reported by Fox (1964) and Hodson (1978) for Merlins in Canada. The importance of the grassland habitat in our study, as represented by the number of radio locations in it, may have been underestimated because of a lack of elevated hunting perches in the form of shrubs or because of difficulty in locating Merlins perched on the ground in broken terrain. Thus, grassland habitat may be more important to hunting Merlins than indicated by the data presented.

The limited use of agricultural habitat by adult male Merlins might have been influenced by a lack of perching sites, difficulty in locating Merlins on the ground, or by lower vegetation diversity and a corresponding lower density of potential prey species. In a study of avian habitat use in central North Dakota, Horned Larks and Vesper Sparrows were two of the most common species observed in croplands; however, of all major habitats sampled, croplands had the lowest breeding bird populations (Faanes 1982). The limited use of croplands by breeding birds was further illustrated by lower species richness, mean density, and species diversity in the North Dakota study.

Higher than expected use of riparian habitats by hunting male Merlins was attributed mainly to the presence of water and food sources that attracted prey species. Also, shrub cover in this habitat likely provided perches for both Merlins and their prey.

The Ponderosa Pine habitat probably is not an important hunting habitat for Richardson's Merlins.

Forest avifauna constituted only 7% of food items identified for this population of Merlins (Becker 1984). However, because nests of the three Merlins in this study were in Ponderosa Pine stands, the birds spent considerable time at or near nest sites between hunting forays.

The patchy shrub cover on four sites regularly used by hunting male Merlins likely provided cover, nesting sites, and perches for prey species. The variety of plant species on these sites may also have provided excellent food sources for passerines. In addition, small depressions in the ephemeral stream bed on the riparian site held water during the entire study period, and was likely important in attracting prey species.

Although shrub density was highly variable on sites where Merlins were regularly observed hunting, it appeared that the presence of some shrubs increased the use of the site by Merlins. Shrubs were probably important to resident birds for elevated singing perches, as well as for hiding and nesting cover. The high variability in shrub densities and heights likely contributed to a diverse prey base. For example, Horned Larks make greater use of sites with low shrub densities, whereas Lark Buntings and Vesper Sparrows are more apt to utilize sites with intermediate to higher shrub densities (Johnsgard 1979).

The results of this study indicated that Merlins used diverse habitat and prey; however, they relied most heavily on the abundant avifauna of sagebrush/grasslands of the shrub-steppe. Management activities that would maintain or increase the natural diversity of these habitats would be beneficial to both Merlins and their prey. Removal of shrubs or conversion of sagebrush/grassland habitat to agricultural cropland could reduce the quality of Merlin hunting habitat. The importance of the Ponderosa Pine habitat on the study area was clearly indicated by the Merlins' exclusive use of this habitat for nesting (Becker 1984). The pine community also provided important perching and roosting sites. Thus, management efforts in the area should be aimed at maintaining Ponderosa Pine and adjacent sagebrush/grassland habitats.

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Literature Cited

- Becker, D. M.** 1984. Reproductive ecology and habitat utilization of Richardson's Merlins in southeastern Montana. M.Sc. thesis, University of Montana, Missoula. 62 pp.
- Beebe, F. L., and H. M. Webster.** 1964. North American falconry and hunting hawks. World Press, Inc., Denver, Colorado. 314 pp.
- Beetle, A. A.** 1970. Recommended plant names. Agricultural Experiment Station Research Journal 31. University of Wyoming, Laramie. 124 pp.
- Bent, A. C.** 1938. Life histories of North American birds of prey. Volume 2. United States National Museum Bulletin 170: 70-83.
- Call, M. W.** 1978. Nesting habitats and surveying techniques for common western raptors. Technical Note TN-316. United States Department of the Interior, Bureau of Land Management, Denver, Colorado. 115 pp.
- Daubenmire, R.** 1959. A canopy coverage method of vegetational analysis. Northwest Science 33: 43-65.
- Ellis, D. H.** 1976. First breeding records of Merlins in Montana. Condor 78: 112-114.
- Faanes, C. A.** 1982. Avian use of Shenyenne Lake and associated habitats in central North Dakota. Resource Publication 144. United States Department of the Interior, Fish and Wildlife Service, Washington, D.C. 24 pp.
- Fox, G. A.** 1964. Notes on the western race of the Pigeon Hawk. Blue Jay 22: 140-147.
- Hodson, K. A.** 1976. The ecology of Richardson's Merlins on the Canadian prairies. M.Sc. thesis. University of British Columbia, Vancouver. 83 pp.
- Hodson, K. A.** 1978. Prey utilized by Merlins nesting in shortgrass prairies of southern Alberta. Canadian Field-Naturalist 92: 76-77.
- Johnsgard, P. A.** 1979. Birds of the Great Plains: breeding species and their distribution. University of Nebraska Press, Lincoln. 539 pp.
- Mohr, C. O.** 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist 37: 223-249.
- Neu, C. W., C. R. Byers, and J. M. Peck.** 1974. A technique for analysis of utilization-availability data. Journal of Wildlife Management 38: 541-545.
- Temple, S. A.** 1972. Systematics and evolution of the North American Merlins. Auk 89: 325-338.

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First Record of the Long-tailed Shrew, *Sorex dispar*, for Nova Scotia

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In August 1984 a single nulliparous adult female Long-tailed Shrew, *Sorex dispar*, was snap-trapped on Folly Mountain, 500 m west-northwest of Folly Lake, Cumberland County, Nova Scotia, in mature deciduous forest growing on steep talus. The specimen is the first record of this species for Nova Scotia and only the seventh record for Canada. Skull and body measurements are compared with those from two New Brunswick *S. dispar* and 11 Nova Scotia *S. gaspensis*.

En août 1984 une seule Musaraigne longicaude, *Sorex dispar* femelle adulte nullipare, fut prise dans une souricière à Folly Mountain, 500 m à l'ouest-nord-ouest de Folly Lake, comté de Cumberland, Nouvelle-Ecosse, dans une futaie de feuillus sur un talus abrupt. Ce rapport est le premier sur cette espèce en Nouvelle-Ecosse et seulement le septième au Canada. Les dimensions du crâne et du corps sont comparés à celles de deux *S. dispar* trouvées au Nouveau-Brunswick et à celles de onze *S. gaspensis* trouvées en Nouvelle-Ecosse.

Key Words: *Sorex dispar*, Long-tailed Shrew, Musaraigne longicaude, *Sorex gaspensis*, Gaspé Shrew, Musaraigne de Gaspé, Nova Scotia.

Until 1984 the Long-tailed Shrew, *Sorex dispar* Batchelder, was known in Canada from only six specimens: four from southeastern Quebec in 1955 (Peterson 1966) and two from Albert County, southeast New Brunswick, in 1978 and 1979 (Kirkland et al 1979; Kirkland and Schmidt 1982). The species is essentially Appalachian, occurring from Maine to North Carolina in the United States (Hall 1981), and is restricted to talus formations in montane or hilly habitats (Handley 1979; van Zyll de Jong 1983).

The closely related and apparently allopatric Gaspé Shrew, *S. gaspensis* Anthony and Goodwin, known from the Gaspé Peninsula and northern New Brunswick, was discovered in Cape Breton Island, Nova Scotia, in 1974 (Roscoe and Majka 1976), and is now known from seven localities on that island (F. W. S., unpublished data). Both species are associated with talus formations, and *S. gaspensis* in Nova Scotia typically occurs in mature, predominantly deciduous, forest growing on a talus substrate.

This paper reports a single *S. dispar* captured during an attempt to find *S. gaspensis* in mainland Nova Scotia. The Cobequid Mountains, in northern mainland Nova Scotia (Figure 1), lie approximately midway between the Cape Breton Island and northern New Brunswick populations of *S. gaspensis* and contain some sites with mature hardwood forest on talus slopes. If *S. gaspensis* occurs anywhere in mainland Nova Scotia, the Cobequid Mountains are a logical place in which to look for it. Of several suitable sites in the Wentworth Valley, the Folly Mountain site was chosen because it was the most accessible.

Locality and Methods

The trapping site was located on the east-facing slope of Folly Mountain, 500 m north-northwest of the north end of Folly Lake, Cumberland County, Nova Scotia (45°33'N, 63°33'20" W) (Figure 1). The habitat was mature deciduous forest dominated by Sugar Maple (*Acer saccharum*), Beech (*Fagus grandifolia*) and Yellow Birch (*Betula alleghaniensis*), growing on an east-facing slope of about 40 degrees, and with a substrate of about 35% talus and 5% rock outcrop. Canopy closure was 70-80%. There was a sparse understory of Striped Maple (*Acer pensylvanicum*), Sugar Maple and Beech. Common ground-cover plants, in order of abundance, were *Oxalis* sp., Spinulose Wood Fern (*Dryopteris spinulosa*), Christmas Fern (*Polystichum acrostichoides*), Wood Aster (*Aster acuminatus*), *Viola* spp. and Wild Sarsaparilla (*Aralia nudicauda*). This vegetation covered about 40% of the ground, with the balance being bare rock, stumps and logs or leaf litter. Mosses were not abundant and were restricted largely to rock substrates and well-rotted wood.

Two parallel traplines were set running east-west up hill and about 20 m apart. Trapping was carried out between 20 and 23 August 1984, using Victor™ snap traps baited with peanut butter and rolled oats. Traps were inserted as far into crevices as possible. Total trapping effort on the two lines was 571 unadjusted trap-nights (TN). Weather during the trapping period varied, with hard rain the first night and clear cool conditions for the remaining two nights.

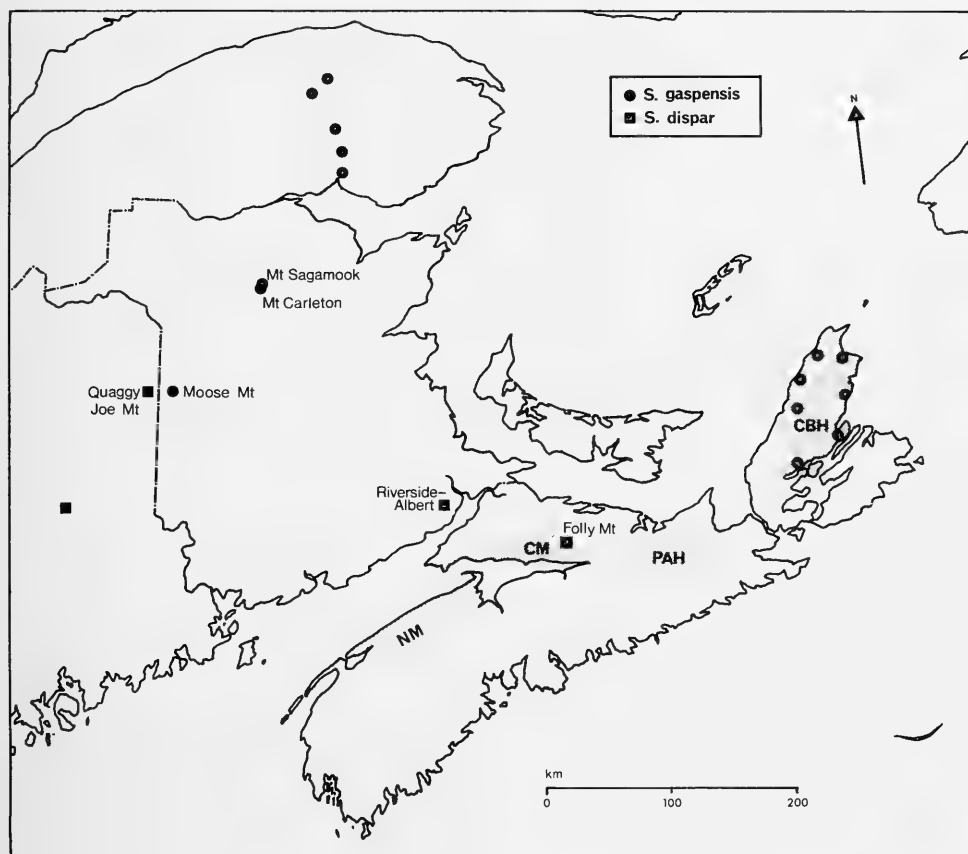


FIGURE 1. The known distribution of *S. dispar* and *S. gaspensis* in the Gaspé Peninsula, eastern Maine, New Brunswick and Nova Scotia, and the physiographic features mentioned in the text. NM = North Mountain. CM = Cobequid Mountains. PAH = Pictou-Antigonish Highlands. CBH = Cape Breton Highlands.

Results

One nulliparous adult female *Sorex dispar* was captured on 22 August 1984 at the uphill end of the more southern of the two traplines. The trap was set under a projecting horizontal tree root which in turn sheltered several crevices between boulders in the talus. The skin, skull and body skeleton of this specimen have been deposited in the collection of the Nova Scotia Museum (catalogue number 984.301.1).

In addition to the single Long-tailed Shrew, three other species (see Table 1) were captured on the talus. A fourth species, *Tamias striatus* (Eastern Chipmunk), was seen alive but not captured. A third trapline was set 100 m to the north along a stream from 21 to 23 August (108 TN) and yielded two species of shrew (*Sorex palustris*, American Water Shrew, and *S. fumeus*, Smoky Shrew) not captured on the

TABLE 1. Small mammal captures on Folly Mountain, 20-23 August 1984.

Species	Talus		along stream (108 TN)
	south line (281 TN)	north line (290 TN)	
<i>Sorex cinereus</i>		1	
<i>Sorex fumeus</i>			1
<i>Sorex dispar</i>	1		
<i>Sorex palustris</i>			1
<i>Clethrionomys gapperi</i>	4	2	4
<i>Napaeozapus insignis</i>	4	3	1
TOTALS	9	6	7
Captures/100 TN	3.2	2.1	6.5

TABLE 2. Comparison of 4 external and 12 skull characters in the New Brunswick and Folly Mountain specimens of *Sorex dispar* with the same characters in 11 Cape Breton Island *S. gaspensis* (weights in grams, all other measurements in millimetres). Because of damage, not all measurements could be taken on each skull.

	N.B. <i>S. dispar</i> #1	N.B. <i>S. dispar</i> #2	Folly Mt. <i>S. dispar</i>	Cape Breton Island <i>S. gaspensis</i>		
				n	\bar{X}	95% confidence interval
Total length	123.00	110.00	120.00	10	105.10	93.37 - 116.83
Tail length	56.00	54.00	58.00	11	48.77	41.60 - 55.94
Hindfoot length	13.00	13.00	12.50	11	11.59	9.70 - 13.48
Weight	4.20	3.60	4.00	9	2.73	1.10 - 4.36
Interorbital breadth	3.15	3.05	3.20	10	3.03	2.88 - 3.18
Molariform tooth row	3.90	3.90	3.95	11	3.59	3.44 - 3.74
Cheek tooth row	4.55	4.60	4.60	11	4.21	4.09 - 4.33
Total tooth row	7.05	7.15	6.70	11	6.32	6.12 - 6.52
Incisor width	1.15	1.25	1.05	10	1.11	1.02 - 1.20
Canine width	1.65	1.60	1.70	11	1.80	1.68 - 1.92
Molar width	3.80	3.65	3.80	11	3.42	3.33 - 3.51
Nasal length	6.25	6.05	6.15	9	5.69	5.32 - 6.06
Palatal length	7.25	6.80	7.00	9	6.39	6.21 - 6.57
Mandible length I	10.15	10.10	10.20	8	9.32	9.09 - 9.55
Mandible length II	11.00	10.75	10.70	5	9.97	9.61 - 10.33
Mandible height	3.20	3.30	3.10	7	3.04	2.87 - 3.21

talus slope (Table 1). The unusual scarcity of *Sorex cinereus*, Common Shrew, on the talus (0.175 captures/100 TN) may have contributed to the capture of the single *S. dispar*, since *S. cinereus* was thus unable to pre-empt a large number of the available traps.

Discussion

The discovery of *Sorex dispar* in Nova Scotia sheds some additional light on the zoogeographic and taxonomic relationships between it and *S. gaspensis*. In the absence of evidence for sympatry, the treatment of the two shrews as separate species has been based on differences in size. Kirkland and Van Deusen (1979) and Kirkland (1981) showed that if the cline of decreasing size from south to north in *S. dispar* was extrapolated northeastwards to *S. gaspensis* localities, it would predict shrews larger than *S. gaspensis*, suggesting that *S. gaspensis* is not a disjunct northern isolate of the same cline. Van Zyll de Jong (1983) pointed out that the gradient of the cline could steepen at its northern end. French and Kirkland (1983) examined 68 Gaspé Shrews collected from two localities in New Brunswick in 1980 and again concluded that *S. gaspensis* is a distinct species. One of these shrews, the specimen from Moose Mountain, New Brunswick, plotted well within the *S. gaspensis* polygon in the discriminant function analysis, despite the fact that it was taken only 28 km east of Quaggy

Joe Mountain, Maine, the northernmost United States locality for *S. dispar* (Figure 1).

The external and skull measurements of the Folly Mountain specimen differ little from those of the two New Brunswick *S. dispar* (Kirkland et al. 1979; G. L. Kirkland, Jr., personal communication), but 11 of 16 measurements fall outside the 95% confidence interval for Cape Breton Island *S. gaspensis* (Table 2). Folly Mountain is approximately 77 km east of the New Brunswick site, or about 25% of the distance between that site and the westernmost Cape Breton Island locality for *S. gaspensis*. The data show no corresponding reduction in the size/distance discontinuity and further support the view that this discontinuity is real.

If the two species are entirely allopatric, the discovery of *S. dispar* at Folly Mountain would indicate that *S. gaspensis* probably does not occur in the Cobequid Mountains. Either species may yet be found in the Pictou-Antigonish Highlands of the eastern Nova Scotian mainland. There are also local talus formations on the south side of North Mountain on the Bay of Fundy shore (Figure 1), which support predominantly deciduous forests and which are apparently suitable habitat for the Long-tailed Shrew.

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National Museum of Natural Sciences, Ottawa, confirmed the identification of the shrew as *Sorex dispar* and had the skull and skeleton cleaned; he also provided measurements of the seven *S. gaspensis* in the National Collection from Cape Breton Highlands National Park, Nova Scotia. Gordon L. Kirkland, Jr., Curator of the Vertebrate Museum, Shippensburg University, Pennsylvania, kindly provided unpublished measurements of the second *Sorex dispar*, collected in Albert County, New Brunswick. Thomas B. Herman, Biology Department, Acadia University, gave useful advice on interpreting measurements. Margaret Anne Hamelin translated the abstract.

Literature Cited

- French, T. W., and G. L. Kirkland, Jr. 1983. Taxonomy of the Gaspé shrew, *Sorex gaspensis*, and the Rock Shrew, *S. dispar*. *Canadian Field-Naturalist* 97: 75-78.
- Handley, C. O., Jr. 1979. *Sorex dispar dispar*. Pp. 541-544 in *Endangered and threatened plants and animals of Virginia*. Edited by D. W. Linzey. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. v + 665 pp.
- Kirkland, G. L., Jr. 1981. *Sorex dispar* and *Sorex gaspensis*. *Mammalian Species* 155: 1-4.
- Kirkland, G. L., Jr., and H. M. Van Deusen. 1979. The shrews of the *Sorex dispar* group: *Sorex dispar* Batchelder and *Sorex gaspensis* Anthony and Goodwin. *American Museum Novitates* 2675: 1-21.
- Kirkland, G. L., Jr., D. F. Schmidt, and C. J. Kirkland. 1979. First record of the Long-tailed Shrew (*Sorex dispar*) in New Brunswick. *Canadian Field-Naturalist* 93: 195-198.
- Peterson, R. L. 1966. *The mammals of eastern Canada*. Oxford University Press, Cambridge. 465 pp.
- Roscoe, B., and C. Majka. 1976. First records for the Rock Vole (*Microtus chrotorrhinus*) and the Gaspé Shrew (*Sorex gaspensis*) from Nova Scotia and a second record of the Thompson's Pygmy Shrew (*Microsorex thompsoni*) from Cape Breton Island. *Canadian Field-Naturalist* 90: 497-498.
- van Zyll de Jong, C. G. 1983. *Handbook of Canadian mammals*. Volume 1. Marsupials and insectivores. National Museums of Canada, Ottawa. 210 pp.

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Body Shrinkage in Young Walleye, *Stizostedion vitreum*, Preserved with AFA, Formalin, Ethanol and Quick Freezing

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Glenn, C. L., and J. A. Mathias. 1987. Body shrinkage in young Walleye, *Stizostedion vitreum*, preserved with AFA, formalin, ethanol, and quick freezing. Canadian Field-Naturalist 101(3): 408-414.

Changes in total length of larval and juvenile Walleye, *Stizostedion v. vitreum*, resulting from delayed fixation and the use of various fixatives were examined over a three-day period. Delayed fixation for up to 30 min after death had no significant effect upon percent shrinkage. Fixation in 5% buffered formalin caused body shrinkage of 2.0%, 2.6% and 7.6% in 26-, 12- and 5-day-old fish, respectively. Shrinkage could be reduced significantly only for the 5-day-old fish by fixing them in AFA (alcohol-formaldehyde-acetic acid) rather than in formalin. Other fixative treatments, such as 70% ethanol or quick-freezing, were less effective in limiting shrinkage in total length.

Key Words: Shrinkage, Walleye, *Stizostedion vitreum*, fixation, AFA, formalin.

Although the pond culture of Walleye, *Stizostedion v. vitreum* (Mitchell 1918) in North America has a 50-year history (Eschmeyer 1950), the ecology of ten stages of the early life history of the walleye has received attention only recently (Cuff 1977, 1980; Li and Mathias 1981; Mathias and Li 1981; Glenn and Mathias 1985). Accurate measurements of larval size are requisite for comparing larval Walleye growth rates in rearing ponds under different management regimes.

Numerous marine studies caution, however, that before comparisons can be made between fish larvae caught in the wild, correction factors for body shrinkage must be applied to length measurements. Body shrinkage in wild-caught larval fish has two components: the first associated with death of larvae in the net; the second due to the effect of the fixative upon body tissues. Blaxter (1971) showed that when Clyde Herring larvae, *Clupea harengus*, were placed live into 4% formalin, they shrank about 12% of their live standard length. The shrinkage occurred in the first day in the fixative. Herring larvae first killed by simulated net capture, on the other hand, shrank about 15% prior to fixation, and shrank a further 5% after fixation.

Other studies have measured the effect of formalin fixation on live larvae of Pacific Herring, *Clupea harengus pallasii* (Hay 1982; Schnack and Rosenthal 1978), Red Sea Bream, *Chrysophrys major* (Rosenthal et al. 1978) and Vendace, *Coregonus albula* (Dabrowski and Bardega 1982). The effects of net capture on shrinkage have been documented for Pacific Herring larvae by Hay (1981) and McGurk (1985), and for northern Anchovy, *Engraulis mordax*, by Theilacker (1980). Both Theilacker (1980) and Hay

(1982, 1984) have shown that a number of other variables such as fish size, fixative and its concentration, salinity, and temperature can affect body shrinkage in larval fishes.

Several studies have suggested that most body shrinkage takes place within the first few days after fixation. Dabrowski and Bardega (1982) showed that *Coregonus* larvae fixed in formalin did not change in length between day 3 and day 285 after fixation. Hay (1981) stated that most shrinkage which had occurred after 60 days in fixed Pacific Herring larvae happened within the first 20 minutes after fixation. Rosenthal et al. (1978) found that the major change in body length observed in formalin-fixed Red Sea Bream larvae occurred within the first 3 days after fixation.

For studies of Walleye growth under pond culture, the optimum fixative would be one which produced minimal shrinkage within 3 days. Rapid assessment of fish growth (within 3 days of capture) allows changes in pond management to be made quickly in response to changing growth patterns. Formalin was tested in this study because it is the most commonly used fixative in fish studies. AFA was tested because it characteristically produces minimal body distortion when used as a fixative for parasitic organisms. Ethanol and quick-freezing were also tested because these treatments are used in our laboratory for preservation of fish for otolith analysis.

The objectives of this study were four-fold:

a) to measure the degree of body shrinkage brought about by formalin fixation over a short (3 day) period,

b) to measure the effects of alternative preservatives (AFA, 70% ethanol and quick-freezing) on body shrinkage over 3 days,

TABLE 1. Experimental design. Groups of ten fish were subjected to each fixation treatment and method. Each group of ten fish was measured live, and then after 30 min, 60 min, 1 d and 3 d. The experimental design was repeated for fish 5 days, 12 days and 26 days old after hatching.

Fixation Method	Fixation Treatment			
	Formalin	AFA	Ethanol	Frozen
1. Killed by fixation	10 fish	10 fish	—	—
2. Killed 10 min prior to fixation	10 fish	—	—	—
3. Killed 30 min prior to fixation	—	—	—	—

c) to determine whether death of the fish prior to fixation (as might occur in a net) affects body shrinkage,

d) to determine whether body shrinkage is a function of fish size. The results will permit correction to be applied to body length measurements of fixed larval Walleye collected with nets and will facilitate rapid assessment of growth in Walleye culture ponds.

Methods

Walleye larvae and juveniles were collected live from a pond using a seine net when they were at post-hatch ages of 5 d, 12 d and 26 d. Five day old prolarvae still contained residual yolk and were at the point of first-feeding. Twelve day old fish were at the postlarval stage and 26 day old fish were juveniles. From a large live sample, groups of 10 fish were removed with a ladle for measurement. Fish in experimental groups (Table 1) were measured under a 20x microscope to the nearest 0.05 mm from the tip of the upper jaw to the end of the caudal fin (total length, TL).

For each age group, 12 groups of 10 fish were used. After live measurement, 4 groups of 10 fish were killed by placing them directly in fixative (Fixation Method 1, Table 1). The fixatives were:

a) 5% formalin, buffered with 20 mL per L of a saturated sodium borate solution;

b) AFA (alcohol-formaldehyde-acetic acid) consisting of 50 parts 95% ethanol, 10 parts 40% formaldehyde solution, 2 parts glacial acetic acid and 38 parts distilled water (Wobeser et al. 1980);

c) 70% ethanol, routinely used as a preservative for otoliths (Methot and Kramer 1979);

d) a quick freezing method. Ninety-five percent ethyl alcohol was cooled to -70°C with dry ice, and fish were dropped into it. Once "instantly" frozen, the fish were removed from the alcohol with forceps and arranged on paper strips in wide mouth jars cooled in a tray of dry ice. The tray, ice, jars and contents were then transferred to a freezer for storage. For measurement, the tray and its contents were brought

to the dissecting microscope. The fish on the paper strips were removed from the bottles and measured under the microscope. Fish remained frozen during measurement.

Eight other groups of 10 fish were subjected to delayed fixation, as might occur if larvae were killed in a net prior to fixation. The live larvae in these groups were measured, then killed by squeezing the brain region with a fine forceps. They were then placed in water for 10 min (Fixation Method 2, Table 1) and 30 min (Fixation Method 3, Table 1) prior to fixation. The 10 and 30 min delays simulated 5 and 25 min net tows, followed by 5 min required to wash the nets. All fish remained in their respective treatments for the duration of the experiment except for the brief intervals required for measurement at 30 min, 60 min, 1 d and 3 d.

Comparison of treatment effects was complicated by the fact that the mean lengths of groups of same-aged live fish at the beginning of the experiment were different ($p < 0.05$, one-way analysis of variance). Therefore, the mean lengths of treated fish were expressed as a percentage difference from their live lengths as follows:

$$\text{experimental mean} = \frac{\text{mean TL of live fish} - \text{mean length of same fish after treatment}}{\text{mean TL of live fish}} \times 100$$

Because experimental mean length was generally between 1% and 15%, an arcsin transformation was applied to all percentage data prior to further analysis of variance.

Results

Delayed fixation for up to 30 min after death did not appear to affect the degree of shrinkage in young Walleye (Table 2). This result was similar for all fixation treatments. A two-way analysis of variance to test for differences among the means of the fixation method (fixation delay) and fixation treatment (type of fixative) showed that there was no statistically

TABLE 2. Mean total length of groups of ten Walleyes subjected to various fixation treatments and methods. Fixation method shows the elapsed time between death and fixation. Standard deviations are shown in parentheses. Percent shrinkage is the percent difference between mean TL at 3 days and mean live TL.

Fish Age	Fixation Method	Fixation Treatment	Total Length (Live)	Total length after				Percent Shrinkage (3d)
				30 min	60 min	1d	3d	
5d	0 min	FORM ¹	9.8(0.19)	9.3	9.3	9.1	9.1	7%
	10 min	FORM	9.9(0.38)	9.4	9.3	9.3	9.2	7%
	30 min	FORM	9.5(0.26)	9.2	9.2	8.9	8.8	7%
5d	0 min	AFA ²	9.9(0.23)	9.9	9.9	9.8	9.6	3%
	10 min	AFA	9.3(0.58)	9.3	9.3	9.0	9.0	3%
	30 min	AFA	9.6(0.34)	9.5	9.4	9.3	9.2	4%
5d	0 min	ETOH ³	9.9(0.33)	9.8	9.8	9.6	9.0	9%
	10 min	ETOH	9.7(0.29)	9.6	9.4	8.9	8.6	11%
	30 min	ETOH	9.6(0.31)	9.5	9.4	9.3	8.7	9%
5d	0 min	FROZ ⁴	9.6(0.24)	8.9	8.7	8.5	8.4	13%
	10 min	FROZ	9.7(0.15)	8.9	8.7	8.6	8.2	15%
	30 min	FROZ	9.8(0.23)	8.9	8.6	8.5	8.3	15%
12d	0 min	FORM	10.9(0.48)	10.7	10.6	10.7	10.6	3%
	10 min	FORM	10.9(0.55)	10.6	10.6	10.7	10.6	3%
	30 min	FORM	11.2(0.32)	10.9	10.9	10.7	10.6	5%
12d	0 min	AFA	11.6(0.61)	11.5	11.4	11.4	11.3	3%
	10 min	AFA	11.3(0.40)	11.1	11.1	11.1	11.1	2%
	30 min	AFA	12.2(0.98)	12.1	11.9	11.6	11.6	5%
12d	0 min	ETOH	11.2(0.69)	11.5	11.0	10.9	10.8	8%
	10 min	ETOH	10.9(0.42)	10.9	10.8	10.5	10.3	6%
	30 min	ETOH	11.7(0.97)	11.5	11.1	10.8	10.7	9%
12d	0 min	FROZ	11.5(0.76)	10.8	10.6	10.6	10.6	8%
	10 min	FROZ	11.5(0.51)	10.8	10.5	10.2	10.2	11%
	30 min	FROZ	11.7(0.69)	10.5	10.4	10.4	10.4	11%
26d	0 min	FORM	30.9(2.09)	30.3	30.3	30.2	30.0	3%
	10 min	FORM	30.8(2.11)	30.7	30.5	30.3	30.2	2%
	30 min	FORM	30.7(1.84)	30.5	30.5	30.3	30.3	1%
26d	0 min	AFA	30.6(3.13)	29.7	29.7	29.6	29.7	3%
	10 min	AFA	30.1(0.98)	29.6	29.4	29.3	29.1	3%
	30 min	AFA	31.3(2.62)	31.0	30.6	30.4	30.3	3%
26d	0 min	ETOH	29.8(1.96)	28.5	28.6	28.5	28.5	4%
	10 min	ETOH	31.2(1.58)	30.0	29.6	29.7	29.5	5%
	30 min	ETOH	31.6(2.61)	31.2	30.0	30.1	30.0	5%
26d	0 min	FROZ	33.1(3.01)	32.9	32.7	32.7	32.3	2%
	10 min	FROZ	31.2(2.05)	30.9	30.8	30.8	30.5	2%
	30 min	FROZ	32.0(2.29)	31.6	31.5	31.4	31.5	2%

¹formaldehyde; ²alcohol-formaldehyde-acetic acid; ³ethylalcohol; ⁴frozen.

discernible effect of method, but that the type of fixative was a highly significant factor ($p < 0.01$), causing shrinkage after 3 days. This result was similar for all ages tested (Table 3a). As a result, the three fixation methods were lumped together in each type of fixative for fish of different ages. The lumped results are shown in Figure 1.

With the exception of AFA, the effect of each fixative upon 3-day shrinkage decreased significantly ($p < 0.05$, one-way ANOVA of 3 day % shrinkage) with fish age and size (Figure 1, A-C and Table 2).

Figure 1 also suggested that fixation in ethanol and by freezing resulted in higher degrees of shrinkage after 3 days than fixation in AFA or formalin. A two-

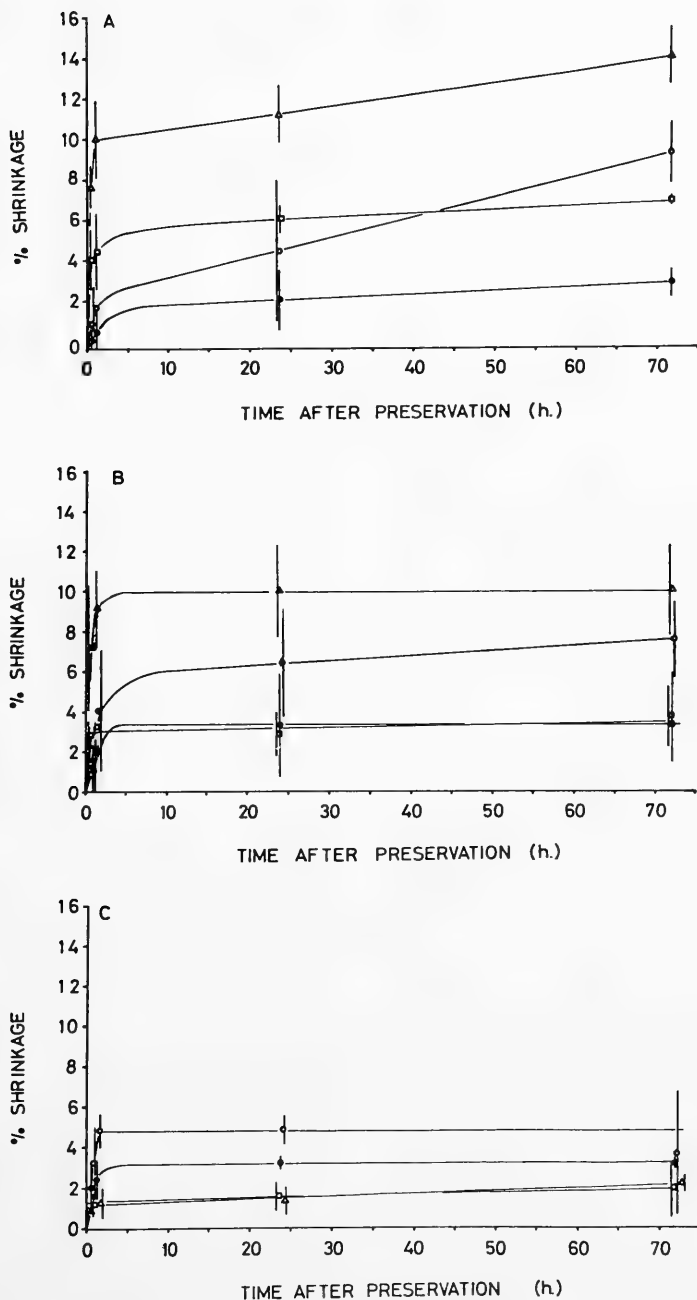


FIGURE 1. Percent reduction in total body length of young Walleyes as a function of the time elapsed since fixation. A—5 day old prolarvae; B—12 day old postlarvae; C—26 day old juveniles. The preservatives were: closed circles — AFA; open circles — ethanol; squares — formalin; triangles — freezing. Vertical lines indicate 95% confidence limits based on the three fixation method means.

way analysis of variance of fixation treatment and time of measurement (Table 3b) indicated that, except for the interaction between ethanol and formalin in 5 day old fish (Figure 1a), the shrinkage due to freezing and ethanol was significantly higher ($p < 0.01$) than shrinkage due to AFA and formalin.

Fixation in ethanol and by freezing were also found to be less satisfactory than the fixation in AFA and formalin. Specimens placed in ethanol became twisted and appeared more dehydrated than fish in the other two chemicals. Frozen fish had a tendency to curve in a lateral direction, making measurement difficult. The frozen fish were also prone to breakage of fins while being handled. For these reasons and the greater degree of shrinkage, ethanol fixation and quick-freezing were not considered useful and did not receive further analysis.

One-way analysis of variance of the time of measurement for 3 ages of fish fixed in AFA and formalin showed that the degree of shrinkage at the different measurement times was highly significant at the 0.01 probability level. Table 4 indicates which of the measurement times had significantly different degrees of shrinkage. Except for 5 days old fish fixed in AFA, shrinkage of fish was statistically discernible after 30 min. Initial shrinkage of 5 day old fish in AFA appeared to be slower than the other fixative-age combinations. In most cases 85% of the total observed

shrinkage was complete at the end of one day. In none of the treatments could a significant difference be shown between percent shrinkage on day one and day three.

Discussion

A number of studies have shown that larval marine fish undergo serious shrinkage as a result of capture in nets and subsequent fixation. Estimates of shrinkage in total length associated with death of the larvae prior to fixation have ranged from 15% in Clyde Herring larvae (Blaxter 1971) to 18% in northern Anchovy larvae (Theilacker 1980), and from 20 to 22% after 1 day in Pacific Herring larvae (Hay 1981). A further 5% shrinkage was estimated by Blaxter (1971) to be due to the effect of the fixative on body tissues. Theilacker (1980) suggested that shrinkage prior to fixation was caused by either (a) the autolysis of tissues as the larvae turn opaque, or (b) osmotic dehydration as a result of osmoregulatory failure.

In our work with pond-cultured larval Walleye, a period of about 10 min can elapse between capture in the net and fixation. Therefore, prefixation shrinkage was of concern. Our results show that there are no differences in body shrinkage between larvae which are killed by fixative, and those which are dead for up to 30 minutes prior to fixation. Thus changes in tissue

TABLE 3a. Two-way ANOVA, showing the effect of fixation treatment and fixation method upon percent shrinkage in young Walleyes after 3 days. **Indicates significance at the 0.01 level and ^{n.s.} indicates no statistical significance. All values rounded to one decimal place from computed values.

Fish age		5 day			12 day			26 day		
Source	df	SS	MS	F	SS	MS	F	SS	MS	F
Total	11	198.9			111.7			16.9		
Treatment (fixative)	3	192.9	64.3	100.6**	93.7	31.2	25.6**	14.3	4.8	11.4**
Method (delay)	2	2.2	1.1	1.7 ^{n.s.}	10.7	5.3	4.4 ^{n.s.}	0.2	0.1	0.2 ^{n.s.}
error	6	3.8	0.6		7.3	1.2		2.5	0.5	

TABLE 3b. Two-way ANOVA, showing the effect of fixation treatment and time of measurement upon percent shrinkage. ** and * indicate significance at the 0.01 and 0.05 levels respectively. ^{n.s.} indicates no significance.

Fish age		5 day				12 day				26 day			
Source	df	SS	MS	F	SS	MS	F	SS	MS	F			
Total	47	844.7			993.6			95.0					
Treatment (fixative)	3	565.5	188.5	125.7**	512.7	113.6	47.8**	54.4	18.1	20.7**			
Time of measurement	3	185.6	61.9	41.3**	340.7	21.4	9.0**	8.1	2.7	3.1*			
Treatment ×													
Time interaction	9	45.5	5.1	3.4**	64.2	3.5	1.5 ^{n.s.}	4.5	0.5	0.6 ^{n.s.}			
error	32	48.0	1.5		76.0	2.4		28.0	0.9				
Duncan's multiple													
Range test ^a	AFA	FORM	ETOH	FROZ	AFA	FORM	ETOH	FROZ	AFA	FORM	ETOH	FROZ	

^alines join treatment levels which are not different at the 0.05 level.

TABLE 4. The mean percent shrinkage of young Walleyes fixed in AFA and formalin, measured at various times after fixation. Means which are not statistically different at the 0.05 probability level (Duncan's multiple range test) are underlined. All analyses were performed on arcsin-transformed data.

Fixative	Fish age (days)	Time of measurement after fixation:				
		0 min	30 min	60 min	1d	3d
AFA ^a	5	0	0.4	0.7	2.5	3.5
AFA	12	0	1.2	2.0	2.8	3.1
AFA	26	0	1.9	2.5	2.9	3.2
FORM ^b	5	0	4.1	4.5	6.4	7.1
FORM	12	1	1.9	2.4	2.3	2.6
FORM	26	0	0.9	1.2	1.7	2.0

^aalcohol-formaldehyde-acetic acid.

^bformalin.

structure following death (autolysis, muscle contraction) contribute little to shrinkage in the absence of fixative. This result contrasts with results from marine larvae, suggesting that pre-fixation shrinkage in the latter is a result of osmotic dehydration. This conclusion is supported also by Hay's (1982, 1984) observations that shrinkage in Herring larvae is directly proportional to the salinity of the medium and to the fixative concentration. We suggest that pre-fixation shrinkage may not be a serious problem for freshwater fish larvae.

Fixation of young Walleye in 5% formalin produced small, but significant degrees of shrinkage by the end of 3 days. The degree of shrinkage was related to fish age, ranging from 7.1% in 5 day old fish, to 2.6% in 12 day old fish and 2.0% in 26 day old fish (Table 4). These results are consistent with those of Dabrowski and Bardega (1982) who reported 3-day shrinkage of 9.7% in "few-day" old Bendace larvae fixed in 10% formalin. Hay (1981, 1982) also found that percent shrinkage in Pacific Herring larvae was inversely proportional to larval fish length, and Theilacker (1980) showed that the percent shrinkage of net-treated, fixed larvae of northern Anchovy was inversely related to fish length. The range of fish sizes in our experiments was not sufficient to derive a predictive relationship between percent shrinkage and fish length.

Of the alternative fixatives tested, only AFA resulted in lower percent shrinkage of larvae than 5% formalin, and this reduction was only statistically significant for 5-day-old larvae (Table 3b). Thus, in the most critical work with Walleye prolarvae up to 5 days of age, percent shrinkage over 3 days can be reduced significantly from about 7% of total live length to about 3.5% by using AFA as a fixative

instead of formalin. Dabrowski and Bardega (1982) found that AFG, an alcohol-formaldehyde-glycerol fixative somewhat similar to AFA, reduced the percent shrinkage of Vendace larvae over three days to 0%. Further work should be done to compare the efficacy of AFA with AFG in fixing prolarval Walleye.

Literature Cited

- Blaxter, J. H. S.** 1971. Feeding and condition of Clyde herring larvae. *Rapports et Procès-Verbaux des Réunions, Conseil international pour l'exploration de la Mer* 160: 128-136.
- Cuff, W. R.** 1977. Initiation and control of cannibalism in larval walleyes. *Progressive Fish-Culturist* 39: 29-32.
- Cuff, W. R.** 1980. Behavioural aspects of cannibalism in larval walleyes, *Stizostedion vitreum*. *Canadian Journal of Zoology* 58: 1504-1507.
- Dabrowski, K., and R. Bardega.** 1982. The changes of fish larvae dimension due to fixation in different preservatives. *Zoologische Jahrbücher. Abteilung für Anatomie und Ontogenie der Tiere* 108: 509-516.
- Eschmeyer, P.** 1950. The life history of the walleye, *Stizostedion vitreum vitreum* (Mitchill) in Michigan. *Bulletin of the Institute for Fisheries Research, Michigan Department of Conservation*, No. 3. 99 pp.
- Glenn, C. L., and J. A. Mathias.** 1985. Circuli development on body scales of young pond-reared walleye (*Stizostedion vitreum*). *Canadian Journal of Zoology* 63: 912-915.
- Hay, D. E.** 1981. Effects of capture and fixation on gut contents and body size of Pacific Herring larvae. *Rapports et Procès-Verbaux des Réunions, Conseil International pour l'exploration de la Mer* 178: 395-400.
- Hay, D. E.** 1982. Fixation shrinkage of herring larvae: effects of salinity, formalin concentration, and other factors. *Canadian Journal of Fisheries and Aquatic Science* 39: 1138-1143.

- Hay, D. E.** 1984. Weight loss and change of condition factor during fixation of Pacific Herring, *Clupea harengus pallosi*, eggs and larvae. *Journal of Fisheries Biology* 25: 421-433.
- Li, S., and J. A. Mathias.** 1981. Causes of high mortality among cultured larval walleyes. *Transactions of the American Fisheries Society* 111: 710-721.
- Mathias, J. A., and S. Li.** 1981. Feeding habits of walleye larvae and juveniles: comparative laboratory and field studies. *Transactions of the American Fisheries Society* 111: 722-735.
- McGurk, M. D.** 1985. Effects of net capture on the postpreservation morphometry, dry weight, and condition factor of Pacific Herring larvae. *Transactions of the American Fisheries Society* 114: 348-355.
- Methot, R. D., Jr., and D. Kramer.** 1979. Growth of northern anchovy, *Engraulis mordax*, larvae in the sea. *United States National Marine Fisheries Service. Fishery Bulletin* 77: 413-423.
- Rosenthal, H., D. Kuhlmann, and O. Fukuhara.** 1978. Shrinkage of newly hatched larvae of the Red Sea bream (*Chrysophrys major* Temminck and Shlegel) preserved in formalin. *Archiv für Fischereiwissenschaft* 29: 59-63.
- Schnack, D., and H. Rosenthal.** 1978. Shrinkage of pacific herring larvae due to formalin fixation and preservation. *Meeresforschung* 26: 222-226.
- Theilacker, G. H.** 1980. Changes in body measurements of larval northern anchovy, *Engraulis mordax*, and other fishes due to handling and preservation. *United States National Marine Fisheries Service. Fishery Bulletin* 78: 685-692.
- Wobeser, G. A., T. R. Spraker, and V. L. Harms.** 1980. Collection and field preservation of biological materials. Pp. 537-551 in *Wildlife management techniques manual*. Edited by S. D. Schemnitz. Wildlife Society, Washington.

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Location and Density of Nests of the Red-tailed Hawk, *Buteo jamaicensis*, in Richmond, British Columbia

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Active Red-tailed Hawk (*Buteo jamaicensis*) nests in Richmond, British Columbia, were documented from 1979 through 1985 at the interface between urban Vancouver and more rural parts of the region. All nests were in deciduous trees (mostly Black Cottonwood, *Populus trichocarpa*) at an average height of 17 m. The average density of nests from 1983 to 1985 (one nest/3.6 km²) is among the highest reported. Current pressures on the habitat and possible factors influencing density include highway and other developments, habitat diversity, food, and lack of interspecific competition.

Key Words: Red-tailed Hawk, *Buteo jamaicensis*, nest density, habitat, urban, British Columbia.

The Red-tailed Hawk (*Buteo jamaicensis*) is found throughout North America in a wide variety of habitats and is a resident in southwestern British Columbia. It is more tolerant of people than most raptor species (S. M. Jackman and J. M. Scott. 1975. Literature Review of Twenty-three Selected Forest Birds of the Pacific Northwest. United States Forest Service. Region 6. 382 pp.). Most previous studies have taken place in locations removed from dense human populations. In eastern Kansas, however, Fitch and Bare (1978) reported that out of a total of 276 nests studied over four years, two nests were in towns and a few were as little as 100 m from buildings.

In this study I document the locations and density of Red-tailed Hawk nesting sites in a rural-urban fringe area of Richmond, British Columbia. Baseline information on a readily observable species could prove useful in monitoring the environmental impact of future development.

Study Area and Methods

Richmond (Figure 1) is within the Vancouver Metropolitan Area (population 1.3 million) and is 12 km south of the most densely populated "downtown" area. Most of the municipality is located on a 115-km² island (Lulu Island) in the mouth of the Fraser River. It is surrounded by two arms of the river and by marshland and the mud flats of Sturgeon Banks. Several small islands in the Fraser River also lie within the municipal boundaries.

The human population (100 000) of Richmond is concentrated on the western half of Lulu Island. The eastern half of the island is predominantly used for agriculture. The study area (Figures 2-5) includes these and other cultivated and uncultivated areas, such as the northern part of Sea Island.

Red-tailed Hawk nests were observed from 1979 through 1985. Searches in 1983, 1984, and 1985 were more extensive than in the four preceding years. I located nests in the winter months when the trees were bare of leaves, as well as during the nesting season. Most nests were easily viewed from roadways with a 20-45X telescope. Monitoring of nests was continued long enough to confirm egg laying and incubation, as evidenced by an adult sitting for prolonged periods in the nest. I used this criterion for designating nests as "active".

To minimize disturbance during nesting, identification of tree species and measurement of the height of the bottom of the nest from the ground were done during fall or winter visits. The height was calculated by viewing the nest through a hypsometer at a measured distance from the tree.

The density of nests was determined annually from 1983 to 1985 by dividing the number of active nests by the study area, determined from a 1:100 000-scale map and a K & E 620000 Planimeter. Approximately 1.8 km² of bog-forest in the study area was difficult to search thoroughly and one or two nests may have been overlooked.

Results

Nesting Period and Locations

Nests were active from at least 22 March to 30 July. The locations of 22 active nests are shown in Figures 2-5. Nests were all located in deciduous trees overlooking an open field, river, or marsh. Two nests were located in fairly dense Paper Birch (*Betula papyrifera*), forests, but were at heights that provided a clear view of the surrounding area. Five nests were on river islands, and four were within 100 m of major highways. Peak-hour traffic on these highways ranged



FIGURE 1. The Township of Richmond.

from 600 to 6000 vehicles per hour. One nest, 50 m away from a heavily-travelled highway, was occupied in at least five of the six study years.

I also observed two active Bald Eagle (*Haliaeetus leucocephalus*) nests within the study area, both within 100 m of the Fraser River. The distance of each of these nests from the nearest active Red-tailed Hawk nest was greater than 1 km.

Red-tailed Hawks may use the same nests in successive or alternate years (Austing 1964). Of 11 nests known to be used in 1983 and which remained intact through 1985, nine were used in each of the three years. Red-tailed Hawks occupied the other two in 1983 only.

Tree and Nest Heights

Of 19 nests, 11 were in Black Cottonwood trees (*Populus trichocarpa*), five in birch, one in a willow (*Salix* sp.), one in an elm (*Ulmus* sp.), and one in a Black Locust (*Robinia pseudoacacia*). The latter two trees are introduced species. The willow nest was unusually low (8 m) and was located on an island.

The heights of 17 nests ranged from 8 to 23 m above the ground, with an average of 17 m. Nesting tree

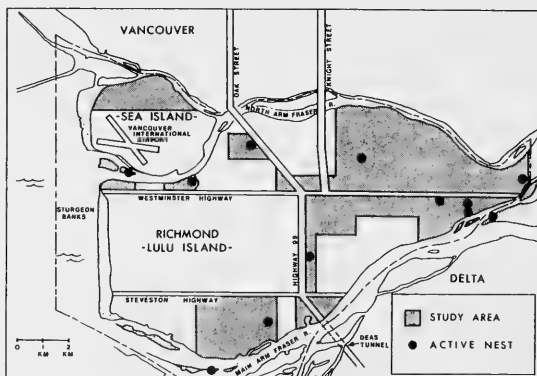


FIGURE 2. Locations of Red-tailed Hawk nests from 1979-1982.

heights ranged from 12 to 38 m, with the average 25 m. Cottonwoods were the tallest species used.

Densities

The numbers of active nests in 1983 to 1985 were 12, 12 and 15, respectively. The average density was 13 nests per 46.7 km² or one nest per 3.6 km². This density was fairly uniform except in the southeast corner (see Figures 2-5). Until 1984, nests were distributed more densely in this area. Two 1983 nests, located near the river, were within 200 m of each other.

Discussion

Red-tailed Hawk nesting densities range from one pair or nest per 1.3 km² to one per 37 km², averaging one nest per 10.1 km² (McInville and Keith 1974; Gates 1972; Luttich et al. 1971; Hagar 1957; Orians and Kuhlman 1956; Craighead and Craighead 1956;

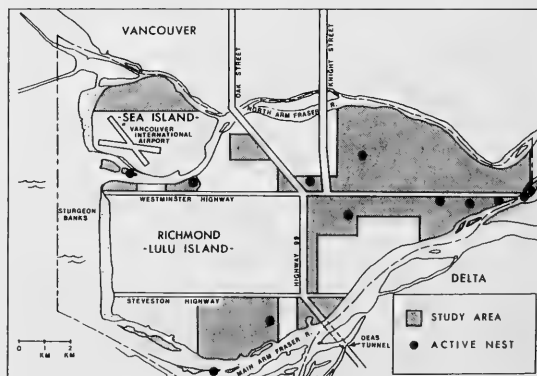


FIGURE 3. Locations of Red-tailed Hawk nests in 1983.

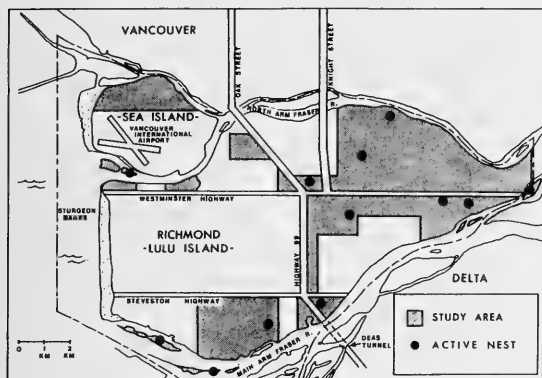


FIGURE 4. Locations of Red-tailed Hawk nests in 1984.

Fitch et al. 1946; Fitch and Bare 1978). The Richmond density of one nest per 3.6 km² is greater than most other densities reported.

A greater-than-average nesting density may be a result of nearby destruction of habitat with expanding development which forces the birds into a smaller area. On the other hand, the combination of open farmland and river edges and islands may provide ideal habitat for the Red-tailed Hawk. Bednarz and Dinsmore (1982), on the basis of results reported by several authors, hypothesized that accessibility in terms of an open flight pathway to the nest is the overriding factor in suitable territories. The many locations at or near the edge of the Fraser River or on islands in the river provide this accessibility. The highest single concentration of nests within the study area prior to 1984 was in the southeast corner of Lulu Island and very near to the river.

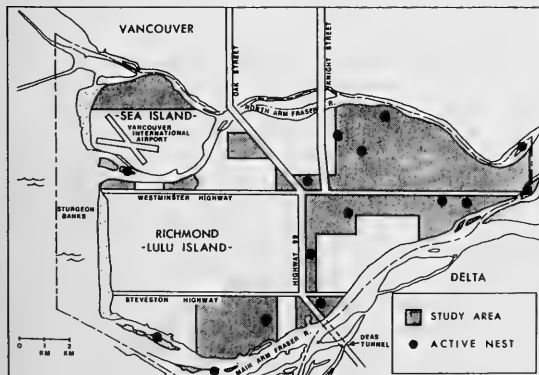


FIGURE 5. Locations of Red-tailed Hawk nests in 1985.

A lack of competition with other raptors may also contribute to a higher-than-average density in Richmond. Interference competition between Red-tailed Hawks and other tree-nesting raptors, particularly Great Horned Owls, *Bubo virginianus*, can reduce Red-tailed Hawk densities (Craighead and Craighead 1956; McInville and Keith 1974; Rothfels and Lein 1983). Other densities reported previously were in areas where Great Horned Owls were nesting in significant numbers (McInville and Keith 1974; Craighead and Craighead 1956; Orians and Kuhlman 1956; Hagar 1957). No Great Horned Owl nests were documented in Richmond during the study period. The other raptors recorded nesting in trees in Richmond from 1979 to 1985 were one Long-eared Owl (*Asio otus*), one Saw-whet Owl (*Aegolius acadicus*), and two Bald Eagles (R. W. Campbell, personal communication). Food supply and other factors could also account for differences in densities among different areas.

Much of Richmond has changed over the last few decades from a rural to an urban area, and that change continues. The largest single development in the near future expected to affect the Red-tailed Hawk population is the construction of a new crossing of the Fraser River and a freeway bisecting the study area. A total of three nesting trees were destroyed between 1979 and 1985. The new freeway, scheduled for construction in 1986 to 1988, will likely destroy one additional nesting tree and come close enough to disturb another. Although the high nesting density within Richmond in 1985 is reassuring, the availability of nest sites can limit Red-tailed Hawk numbers (Soltz 1984; Schmutz et al. 1980). Tall trees and other perches are also important for reproductive success (Janes 1984; Fitch et al. 1946).

Further monitoring of nests may give an indication of the limits of adaptability of this species to urban encroachment. A comparative study in a more rural area of the Fraser River valley would also be of interest. Although Red-tailed Hawks are abundant in British Columbia and their population is thought to be stable (Fyfe 1976), the management objectives for all raptors in the province include the maintenance of viable populations within historical ranges (W. T. Munro. 1979. Preliminary Raptorial Bird Management Plan for British Columbia. British Columbia Ministry of Environment. 17 pp.). In an area like the Greater Vancouver Region, this highly visible species also offers educational and recreational values to the urban population. I hope that we can maintain a viable population of this and other raptors in the Lower Fraser River.

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Literature Cited

- Austing, G. R. 1964. The world of the Red-tailed Hawk. J. B. Lippincott, Co., Philadelphia, Pennsylvania.
- Bednarz, J. C., and J. J. Dinsmore. 1982. Nest sites and habitat of Red-shouldered and Red-tailed Hawks in Iowa. Wilson Bulletin 94(1): 31-45.
- Craighead, J. J., and F. C. Craighead. 1956. Hawks, owls and wildlife. Stackpole Co., Harrisburg, Pennsylvania, and Wildlife Management Institute, Washington, D.C.
- Fitch, J. S., F. Swenson, and D. F. Tillotson. 1946. Behavior and food habits of the Red-tailed Hawk. Condor 48: 205-237.
- Fitch, J. S., and R. O. Bare. 1978. A field study of the Red-tailed Hawk in eastern Kansas. Transactions of the Kansas Academy of Science 81(1): 1-14.
- Fyfe, R. W. 1976. Status of Canadian raptor populations. Canadian Field-Naturalist 90(3): 370-375.
- Gates, J. M. 1972. Red-tailed Hawk populations and ecology in east-central Wisconsin. Wilson Bulletin 84: 421-433.
- Hagar, D. C., Jr. 1957. Nesting populations of Red-tailed Hawks and Horned Owls in central New York State. Wilson Bulletin 69: 263-272.
- Janes, S. W. 1984. Influences of territory composition and interspecific competition on Red-tailed Hawk reproductive success. Ecology 65(3): 862-870.
- Luttich, S. N., L. B. Keith, and J. D. Stephenson. 1971. Population dynamics of the Red-tailed Hawk (*Buteo jamaicensis*) at Rochester, Alberta. Auk 88: 75-87.
- McInville, W. B., Jr., and L. B. Keith. 1974. Predator-prey relations and breeding biology of the Great Horned Owl and Red-tailed Hawk in central Alberta. Canadian Field-Naturalist 88: 1-20.
- Orians, G., and F. Kuhlman. 1956. Red-tailed Hawk and Horned Owl populations in Wisconsin. Condor 58: 371-385.
- Rothfels, M., and M. Ross Lein. 1983. Territoriality in sympatric populations of Red-tailed Hawks (*Buteo jamaicensis*) and Swainson's Hawks (*Buteo swainsoni*). Canadian Journal of Zoology 61(1): 60-64.
- Schmutz, J. K., S. M. Schmutz, and D. A. Boag. 1980. Coexistence of three species of hawks (*Buteo* spp.) in the prairie-parkland ecotone. Canadian Journal of Zoology 58: 1075-1089.
- Soltz, R. L. 1984. Time and energy budgets of the Red-tailed Hawk (*Buteo jamaicensis*) in southern California. Southwest Naturalist 29(2): 149-156.

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Late Quaternary Zoogeography of the Northern Pocket Gopher, *Thomomys talpoides*, in Southwestern Alberta

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Burns, James A. 1987. Late Quaternary zoogeography of the Northern Pocket Gopher, *Thomomys talpoides*, in southwestern Alberta. *Canadian Field-Naturalist* 101(3): 419–422.

In Alberta, the Northern Pocket Gopher, *Thomomys talpoides*, is typically a species of the parklands and grasslands. However, recent evidence (1969–1984) has revealed that gophers have extended their range into the Rocky Mountains of southern Alberta in at least five locations. Mid-Wisconsin Interstadial fossils of these animals have also been identified from two caves in the Front Range. It has been suggested that the effects of grazing contribute to the spread of gophers. It is suggested here that a similar relationship may have existed in the past between bison and gophers. Expansion of gopher distribution into the mountains receives support from both late Quaternary and recent findings.

Key Words: Northern Pocket Gopher, *Thomomys talpoides*, Quaternary, Alberta, zoogeography.

Wilson (1969) reported sightings, unearthed skulls, and fresh burrows of the Northern Pocket Gopher, *Thomomys talpoides*, from several localities in Alberta, and thus extended to the west the range depicted by Soper (1964). From 1974 to 1977, I made personal field observations of pocket gophers in the Rocky Mountains during paleontological investigations of two mountain caves. The recent evidences complemented the recovery from the caves of 88 fossils referable to *Thomomys talpoides*. The recent and fossil records are extra-limital (relative to the range for *T. talpoides* depicted by Soper (1964) and MacDonald (1969)); together they lead to the suggestion of a relationship between these western occurrences of pocket gophers and the presence of large ungulates.

Recent Observations

Subsequent to Wilson's (1969) reports, gophers have been observed in the mountains on several occasions. In August 1978 I confronted, and attempted to trap, an individual at Indian Grave campground (locality 5, Figure 1) on Highway 532 near the confluence of Johnson and Willow creeks, 11 km northwest of Chain Lakes Provincial Park. Mounds were abundant in a sandy loam substrate that supported a mixed poplar-conifer forest. The locality lies at an elevation of 1493 m and is 5–6 km east of the mountain front.

In 1978, during exploration in the subalpine zone of Plateau Mountain north of the intersection of the Kananaskis Forestry Trunk Road and Highway 532, I discovered about 20 gopher mounds that appeared fresh at an elevation of 2225 m (locality 4, Figure 1). No bones or live animals were observed. In August 1984 I observed similar mounds at the same locality.

These mounds appeared to be fresh and I interpreted them as an active colony, assuming that erosion would have erased abandoned mounds. The substrate is friable shale on a gentle slope that steepens as it enters the valley of a small intermittent creek. Forested areas in the locality are dominated by Lodgepole Pine, *Pinus contorta*, and Subalpine Larch, *Larix lyallii*; the conspicuous mammalian community includes Columbian Ground Squirrel, *Spermophilus columbianus* and Red Squirrel, *Tamiasciurus hudsonicus*.

M. C. Wilson (personal communication) observed gopher mounds (August–September 1983) in four locations (locality 3, Figure 1) just east of Hailstone Butte off Highway 532 near “the Hump,” a local divide at 2010 m. The localities range in elevation from 1890 to 2100 m. He had observed mounds previously at a campground (locality no. 6, Figure 1) on Oldman River west of its confluence with the Livingstone River, at an elevation of 1493 m (Wilson 1969 and personal communication). Specimen evidence had been secured from the locality in 1952 as UA537 and 538 in the University of Alberta Zoology Museum. He also observed burrows (personal communication) along Highway 1A west of Fort Creek (locality 1, Figure 1). This observation suggests invasion of the mountains via the Bow River Valley. Wilson's (1969) upper Sheep River locality (no. 2, Figure 1) nearly coincides with University of Alberta record UA9011 taken on Mt. Rae in 1973.

M. J. Dorrance (personal communication) learned through informants that pocket gophers were absent, or at least uncommon, in the foothills west of Nanton, Alberta, when settlers first arrived in the 1890s, a situation that began to change noticeably by the 1920s. This suggests a correlation between range extension of gophers and the rise in domestic stock grazing.

Thus, five localities [Barrier Lake, 51°02'N, and Sheep River valley, 50°35'N (Wilson 1969); Plateau Mountain, 50°14'N; Livingstone Gap, 49°50'N; Bow valley, 51°09'N (this report)] may represent invasion routes that permitted pocket gophers to colonize the mountains from the Alberta foothills.

Fossil Records

Evidence of pocket gophers also comes from paleontological excavation at two caves in the Rocky Mountains of Alberta (Burns 1984; localities A and B, Figure 1). January Cave is located on the west flank of Plateau Mountain overlooking the Kananaskis Forestry Trunk Road, about 27 km due west of Chain Lakes Provincial Park. This cave, at an elevation of 2040 m, is a limestone solution cavity with about 2 m of sediments containing fragmentary vertebrate remains deposited almost exclusively by raptorial birds (Burns 1984). Dates indicate that infill took place during the mid-Wisconsin Interstadial, a period during the last stage of the Pleistocene when the landscape was ice-free and the climate was perhaps as mild as today: 23 100 ± 860 rcybp (radiocarbon years before present), 31 900 ± 1400 rcybp and 33 500 ± 1100 rcybp, laboratory numbers GaK-5438, QL-1738, QL-1737.

Pollen analysis (in Burns 1984) of the cave deposits indicates full tundra conditions locally with a large component of tundra "cushion" plants (Caryophyllaceae), grasses (Gramineae), minor amounts of sage (*Artemisia*), but never more than 7% arboreal pollen (*Pinus*, *Picea*, *Abies*, *Betula*, *Alnus*, *Quercus*). The cave produced evidence of 34 mammalian species, 17 of which are rodents, and of those, eight are obligate burrowers like the pocket gopher. Although not plentiful, the pocket gopher was certainly a member of the local fauna 33 000 years ago within the montane zone.

The second fossil locality is Eagle Cave in the Crowsnest Pass of extreme southwestern Alberta, about 10 km west of Coleman. The cave is a limestone solution cavity at an elevation of 1377 m. The sediments were deposited during the mid-Wisconsin Interstadial (dates: 22 700 ± 1000 rcybp (GaK-2336) and > 33 000 rcybp (S-1963)), and in the later postglacial period. The records of pocket gopher bones and teeth from sediments of both intervals, like those of January Cave, are well within the montane zone in Alberta.

Indigenous to North America, *Thomomys talpoides* has been found at several Pleistocene localities, the earliest known being of Sangamon Interglacial age at Medicine Hat, Alberta (Kurtén and Anderson 1980: 225; cf. Stalker and Churcher 1982) dating roughly to 100 000 y BP. All previously

reported late Wisconsin occurrences of *Thomomys talpoides* are from south of the continental ice sheet margin (Kurtén and Anderson 1980).

Ecology, Distribution and Inference

Pocket gophers are colonial, mainly nocturnal, and are active year-round (Soper 1964). They consume perennial, broad-leaved forbs and grasses (Miller 1964; Banfield 1974). Aspen parkland and prairies are typical habitat for this adaptable species in Alberta (Soper 1964), but foothills and suitable areas at higher elevations in the western mountain states are inhabited (Miller 1964). The gopher's recent range expansion into the mountains of Alberta may relate to the animal's ability to exploit overgrazed rangelands (Banfield 1974). The Rocky Mountain Forest Reserve, significantly including the Plateau Mountain area, is used for open-range cattle grazing.

Soper (1964) suggested an altitudinal limit for gophers in Alberta of 4700 ft. (1432 m), but recent observations (MacDonald 1969; Wilson 1969; this report) extend the limit to at least 7300 ft. (2225 m). Miller (1964) argued that availability of suitable soils for burrowing seems to limit range expansion. Johnstone (1954) argued that major rivers serve as barriers to immigration. Dalquest and Scheffer (1944) identified forests as barriers but river valleys as immigration routes for gophers in Washington state. Elevation is another form of barrier, although it may be related to temperature and soil suitability. Nevertheless, pocket gophers are generally found at lower elevations in the north and at progressively higher elevations in the south. They occur up to 3500 m (11 500 ft.) in Colorado (Armstrong 1972).

As neither soil types, watercourses, nor elevation act effectively as barriers to the incursion of pocket gophers in the Front Ranges of the Rocky Mountains in Alberta, what conditions promoted the entry of the gophers into the subalpine zone in the past and again very recently? One inference is cogent, namely that cattle grazing in the foothills and in the Bow-Crow Forest Reserve promotes forage conditions favoured by gophers (see Banfield 1974: 149).

Substitute "bison" for "cattle" in the equation and a possible mechanism of past gopher incursions becomes apparent. In support of this, bison teeth (species indeterminate) are known from the interstadial levels of Eagle Cave, and postglacial occurrences of bison fossils are known from along the eastern flanks of the mountains. Incursions of gophers may have proceeded one or more times in synchrony with the influx of the large ungulate grazers, but evidence of multiple incursion is wanting.

The question of the geographic origin of pocket gophers in the fauna of the Crowsnest Pass cannot be

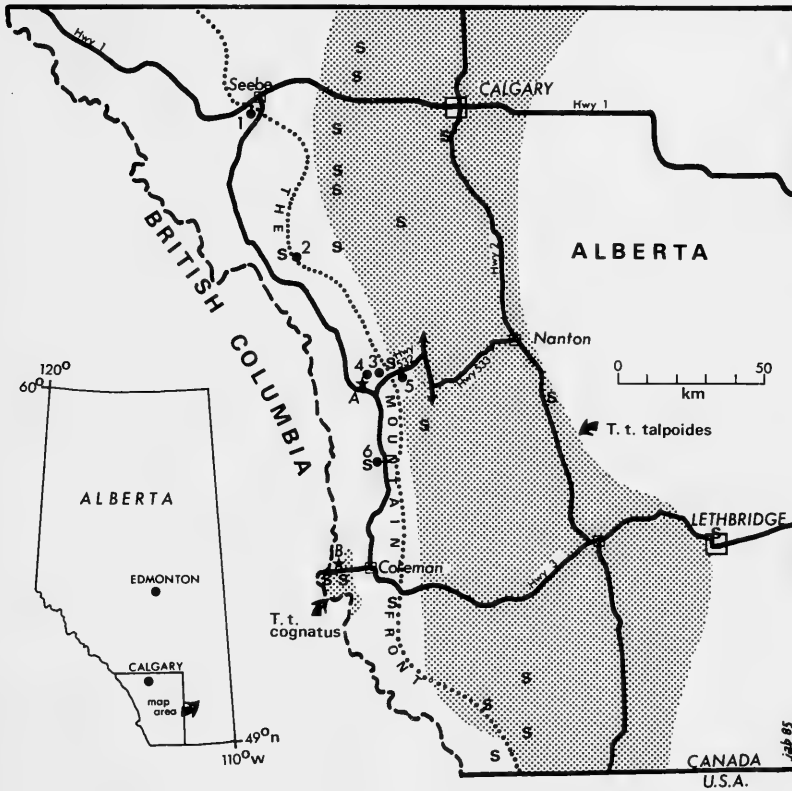


FIGURE 1. Location of fossil and recent occurrences of *Thomomys talpoides* in Alberta mentioned in text. Stippled area denotes recent distribution in Alberta of two subspecies of *T. talpoides* (after MacDonald 1969). Fossil sites (stars): A — January Cave; B — Eagle Cave. New recent records (black dots): 1 — Barrier Lake; 2 — Upper reaches of Sheep River; 3 — four sites near Hailstone Butte; 4 — West flank of Plateau Mountain; 5 — Indian Grave campground; 6 — Oldman River campground. Specimens preserved in collections of the Provincial Museum of Alberta and the University of Alberta (Zoology) are denoted by "S".

resolved through study of the fossils. Soper (1964) noted that *T. talpoides cognatus* in Alberta is probably a recent immigrant from British Columbia where it inhabits a restricted range (Cowan and Guiget 1965). There is no evidence to date that the ranges of *T. t. cognatus* and *T. t. talpoides* (the adjacent race in Alberta) have overlapped. The great variability in skull size and shape among the races of *Thomomys* (Dalquest and Scheffer 1944; Miller 1964) renders subspecific identification of the cave fossils impossible.

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Literature Cited

- Armstrong, D. M.** 1972. Distribution of mammals in Colorado. University of Kansas Museum of Natural History Monograph 3. 415 pp.
- Banfield, A. W. F.** 1974. The mammals of Canada. National Museums of Canada and University of Toronto Press, Ottawa and Toronto. 438 pp.
- Burns, J. A.** 1984. Late Quaternary palaeoecology and zoogeography of southwestern Alberta: vertebrate and palynological evidence from two Rocky Mountain caves. Ph.D. dissertation, University of Toronto, Toronto, Ontario. 306 pp.
- Cowan, I. McT., and C. J. Guiguet.** 1965. The mammals of British Columbia. Handbook No. 11. British Columbia Provincial Museum, Victoria, British Columbia. 414 pp.
- Dalquest, W. W., and V. B. Scheffer.** 1944. Distribution and variation in pocket gophers, *Thomomys talpoides*, in the state of Washington. The American Naturalist 73: 308-333.
- Hall, E. R.** 1981. The mammals of North America. Second edition. John Wiley, New York. 1180 pp.
- Johnstone, W. B.** 1954. A revision of the pocket gophers *Thomomys talpoides* in British Columbia. Canadian Field-Naturalist 68: 155-164.
- Kurtén, B., and E. Anderson.** 1980. Pleistocene mammals of North America. Columbia University Press, New York. 442 pp.
- MacDonald, S. J.** 1969. A taxonomic study of the pocket gophers of Alberta, Mammalia: Geomyidae: *Thomomys talpoides* (Richardson). M.Sc. thesis, University of Alberta, Edmonton, Alberta. 70 pp.
- Miller, R. S.** 1964. Ecology and distribution of pocket gophers (Geomyidae) in Colorado. Ecology 45(2): 256-272.
- Soper, J. D.** 1964. The mammals of Alberta. The Hamly Press Ltd., Edmonton, Alberta. 402 pp.
- Stalker, A. MacS., and C. S. Churcher.** 1982. Ice age deposits and animals from the southwestern part of the Great Plains of Canada. Geological Survey of Canada Miscellaneous Report 31 (wall-chart).
- Wilson, M.** 1969. Comments on the range of the northern pocket gopher in Alberta. The Blue Jay 27(4): 225-226.

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Distribution and Movements of Caribou, *Rangifer tarandus*, in the Central Arctic Region of Alaska

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The annual distribution patterns of Barren-ground Caribou (*Rangifer tarandus granti*) in the Central Arctic region of Alaska were consistent over a three-year period. Caribou wintered in the northern foothills of the Brooks Range, and in spring at least one-half of the animals migrated west out of the study area and the remainder drifted north towards the coast. By mid-May, cows had reached calving areas along the coastal plain between the three major rivers in the study area (Colville, Sagavanirtoke and Canning). Caribou dispersed over the coastal plain in June but by July they were highly aggregated near the coast and river deltas. From August to October, Caribou dispersion increased southwards until October when 82 percent of the study area was occupied. Influxes of Western Arctic herd and possibly Porcupine Caribou herd animals occurred in the fall when at least twice as many Caribou were in the study area as in June. Continued growth of the Western Arctic and Porcupine herds will likely result in increasing numbers of Caribou using the Central Arctic region. Changes in distribution and movements are likely to occur as numbers increase or decrease. These changes must be considered when evaluating the effects of oil development activities on Caribou in the region.

Key Words: Barren-ground Caribou, *Rangifer tarandus granti*, Arctic, distribution, Alaska, oil development.

The recent rediscovery and growth of a Barren-ground Caribou, *Rangifer tarandus granti*, sub-population in the Central Arctic region of Alaska has raised questions concerning interactions of adjacent Caribou herds and the evaluation of the effects of human development (Bergerud et al. 1984). The Caribou of the Central Arctic region of Alaska were first designated as the Central Brooks Range herd by Skoog (1968). During the period 1910 to 1959 this herd supposedly existed intermittently as a result of range changes and immigration from the neighbouring Western Arctic and Porcupine Caribou herds (Skoog 1968).

Hemming (1971) suggested that the region served as an overlap zone between these two herds, whereas Roseneau et al. (1974) provided evidence for the existence of both a distinct herd and an overlap zone in the region. In 1976, Cameron and Whitten (1979) reported a discrete sub-population located between the Colville and Canning rivers and north of the Brooks Range, which they designated the Central Arctic herd. This sub-population increased from 5000 animals in 1975 to 13 000 in 1983 (Whitten and Cameron 1983).

The discovery of oil at Prudhoe Bay in 1968 and the subsequent construction of the Trans-Alaska Pipeline System (TAPS) prompted the first monitoring of Caribou in the region beginning in 1969 (Gavin 1979). In 1975 the Alaska Department of Fish and Game began a long-term study of the Central Arctic herd in

relation to TAPS (Cameron and Whitten 1980). However, the seasonal distribution and movements of the herd have not been described in detail over the entire range of the herd (Gavin 1979; Cameron and Whitten 1979).

The present study was undertaken as part of a larger study aimed at assessing the influence of TAPS on Caribou in the Central Arctic region. In assessing the environmental significance of human activities, it is important to understand the seasonal distribution of a highly mobile species such as Caribou. For this reason we investigated the distribution of the Central Arctic herd in relation to TAPS and adjacent Caribou herds.

Study Area

The study area, located in northern Alaska, covers approximately 46 000 km² and is bounded to the north by the Beaufort Sea and to the south by the Brooks Range (Figure 1).

The area is treeless and ranges in elevation from 0 to 1500 m above sea level (asl), with drainages oriented south to north. The three physiographic provinces represented in the area are the Arctic coastal plain, the Arctic foothills, and the Arctic mountains (Spetzman 1959; Wahrhaftig 1965). The study area has a Continental climate characterized by long, cold winters with short day lengths and short cool summers (Benson et al. 1975). Annual snowfall and precipitation increase from the coast to the Brooks Range (Selkregg 1975).

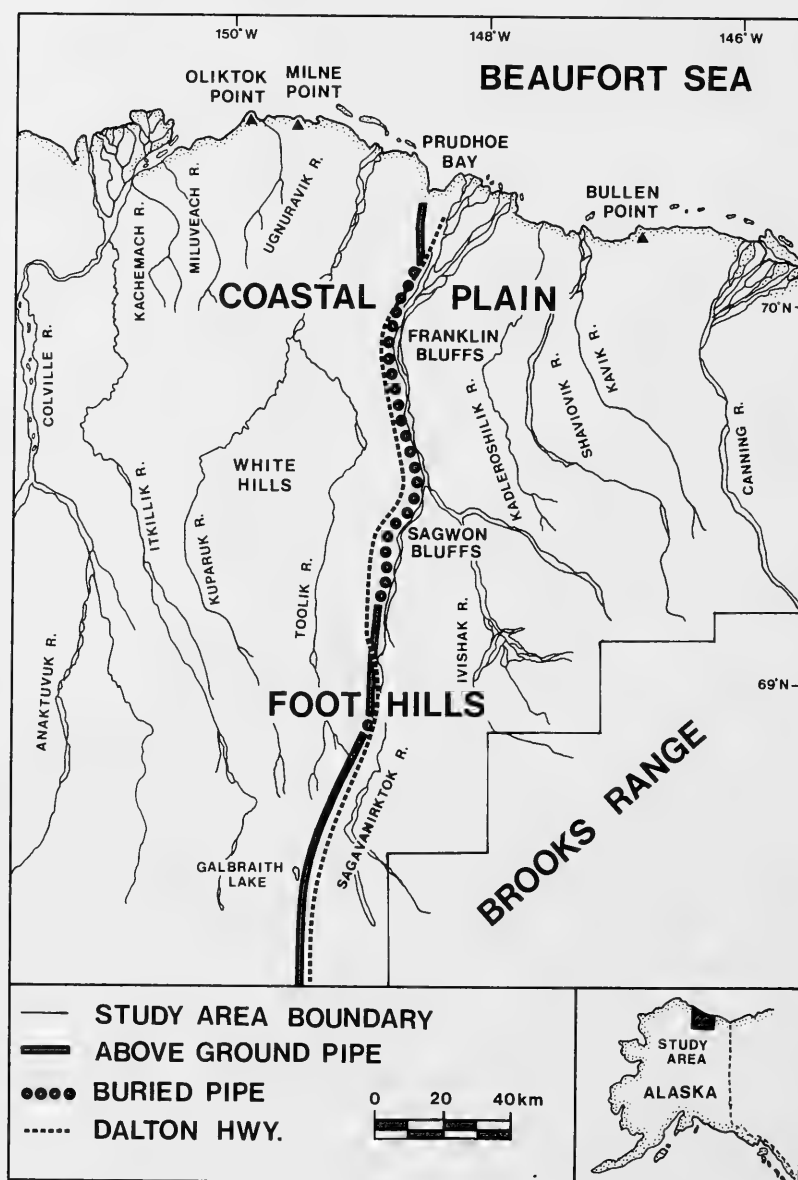


FIGURE 1. The Central Arctic study area.

Methods

The distribution of Caribou was measured by systematically sampling without replacement (Caughley 1977) using the strip transect method (Eberhardt 1981). From 1981 to 1983, 19 aerial surveys of the study area were conducted at 10 percent sampling intensity over seven Caribou life-cycle phases: winter (March-April); spring (May); calving

(June), post-calving (July); August dispersal (August); pre-rut (September); rut (October). One survey was conducted during each life cycle phase each year except during 1981, when the late winter and spring surveys were not conducted. A mid-June intensive survey (30% coverage) was conducted each year over the coastal lowlands. On intensive surveys, transects extended south of the coast only as far as

calves had been observed during a previous two-day reconnaissance survey.

Helio-courier or Cessna 206 aircraft were flown at 160 km/h indicated air speed at 120 m above ground level. Transect width was 2.0 km and transects were systematically oriented north-south over the study area at 20 km intervals.

To estimate and describe Caribou distribution graphically, densities of Caribou observed on transects were extrapolated to the entire study area. Transects were divided into 119 cells, each 20×2 km, and densities within these cells were extrapolated to 20×20 km cells (100% of study area). Caribou densities for the 400-km² cells were then averaged over the three years. The frequency of occurrence of Caribou within each cell was determined to measure consistency of use of specific areas. Total numbers of Caribou in the study area were determined based on 10% survey coverage.

Based on a comparison with our more intensive survey coverage (30%), summer distribution reported by Lawhead and Curatolo (1984), and with Alaska Department of Fish and Game's intensive calving surveys (Whitten and Cameron 1985), 10 percent systematic survey coverage gave a reasonable account of Caribou distribution.

Results

Distribution and Movements

Annual Cycle: Caribou occupied, on average, 61 percent of the study area at a density of at least 1 Caribou/100 km² during the seven life cycle phases (Table 1). However, the number and dispersion of Caribou varied throughout the year. This variation was reflected in the proportion of the study area occupied by Caribou (Figure 2). Dispersion was greatest during the rut, when 82 percent of the region

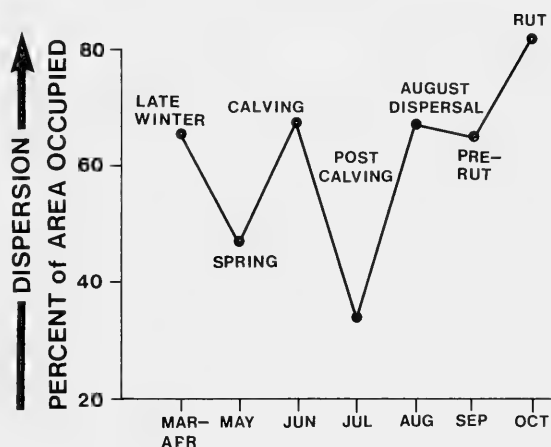


FIGURE 2. Caribou dispersion based on average percent of study area occupied, March through October 1981-1983.

was occupied, and least during the post-calving insect-relief season when aggregation resulted in only 34 percent of the region being occupied. Moderate aggregation was noted in spring followed by subsequent dispersal during calving.

Based on the average density in each cell over three years, a high proportion of the study area (65%) was either unoccupied by Caribou or supported low densities (<11 caribou/100 km²) (Table 1). High densities (>25 caribou/100 km²) occurred over an average of 19 percent of the study area. The number of high density cells in the study area increased at an annual rate of 24 percent from 1981 to 1983 (Table 2). This increase in overall density reflects herd growth and periodic influxes of caribou from adjacent regions. Influx was most obvious during the rut and late winter, when high caribou density occurred over 28 to 41 percent of the study area compared to an average of 13 percent from May to September.

Late Winter: During late winter the majority of Caribou occupied the southern part of the study area with high densities in the foothills, especially in the southwest (Figure 3). The distribution in this area was similar in both 1982 and 1983 (late winter surveys were not conducted in 1981). In both years we also found moderate-to-high densities in the northwest and northeast corners of the study area. Low densities of wintering Caribou occurred up to 100 km south of the coast between the Colville and Kuparuk rivers, but there was considerable variability in areas occupied between years.

TABLE 1. Number of 400-km² cells occupied by Caribou in four density classes based on average density over three years, 1981 to 1983 (total cells in study area = 119).

Life Cycle Phase	Number of Caribou/100 km ²				
	0	1-10	11-25	26-50	>50
Winter	43	28	15	16	17
Spring	63	30	14	10	2
Calving	39	31	26	20	3
Post-calving	78	26	2	7	6
Dispersal	39	44	25	4	7
Pre-rut	42	27	29	11	10
Rut	21	26	23	22	27
Mean	46	30	19	13	10
SE	8	3	4	3	4

TABLE 2: Number of 400-km² cells occupied by high densities (>25 Caribou/100 km²) of Caribou in 1981, 1982 and 1983.

Life cycle Phase	1981	1982	1983	Average Increase
Winter	—	16	31	1.94
Spring	—	10	12	1.20
Calving	17	16	24	1.22
Post-calving	9	6	4	0.67
Dispersal	10	10	19	1.45
Pre-rut	14	33	17	1.44
Rut	18	48	41	1.76
Mean	14	20	21	1.24
SE	2	6	5	1.92

Spring: By late May, there were two concentrations of pregnant females and juveniles in 1982 and 1983 (Figure 4). The highest densities occurred between the Colville and Kuparuk rivers up to 120 km south from the coast and between the Canning and Kavik rivers within 50 km of the coast. Both locations, representing 11 percent of the study area, were used in both years surveyed.

Movements of Caribou within the study area during spring were characterized more by shifts in density than by discrete columnar movements which are usually shown by other Caribou herds during spring migration (Kelsall 1968). Caribou trails were scattered with no indication of large numbers of animals migrating along a specific route.

Calving: By mid-June, 8–10 days after the peak of calving, Caribou were more dispersed throughout the northern two-thirds of the study area than in May (Figure 5). The distribution at that time reflected the continued northward movement of bulls and dispersal of cows and calves over the coastal plain. Highest densities were consistently found between the Canning and Kavik rivers and between the Kuparuk River and Oliktok Point. Low densities were associated with coastal river deltas and the southern part of the study area.

Because of local weather conditions, the western and eastern extremities of the study area were not surveyed during mid-June in 1981, and in 1982 the area between the Sagavanirktok and Kavik rivers received incomplete coverage. However, on the basis of reconnaissance surveys and data from other years, the foregoing areas were probably used by cows and calves. Calves were distributed within the same general area in all years, although in 1983 calves were located farther south than in other years as a result of a late spring which delayed northward movements of some pregnant cows. The highest numbers of calves

during all survey years were located between the three major rivers (Colville, Sagavanirktok and Canning) and within 60 km of the coast (Figure 6).

Post-Calving: In early July, Caribou sought habitats offering relief from mosquitos (*Aedes* spp.). They formed large aggregations along the coast and on river deltas which are sparsely vegetated and exposed to onshore winds. Dispersion was lowest at this time, with most Caribou aggregated along the coast and in river valleys which served as corridors for movement to the coast (Figure 7). Caribou concentrations occurred between the Kuparuk River and Oliktok Point, and between the Sagavanirktok and Kavik rivers. Caribou shifted their distribution between the coastal and inland areas depending on weather conditions which affected mosquito activity (White et al. 1975; Lawhead and Curatolo 1984). Thus, in 1982, virtually all Caribou were within 30 km of the coast, but in 1981 and 1983, most caribou were within 60 km of the coast.

August Dispersal: In August, oestrid flies succeeded mosquitos as the major insect pest that harassed Caribou. Dispersion increased dramatically after mid-July (Figure 2), with most caribou occupying the northern two-thirds of the area (Figure 8). High densities were most common immediately east of the

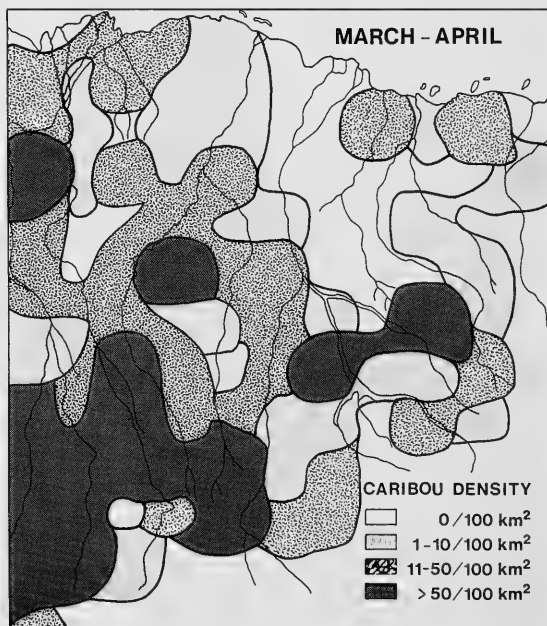


FIGURE 3. Average Caribou density in the Central Arctic region in March-April based on 1982 and 1983 surveys.

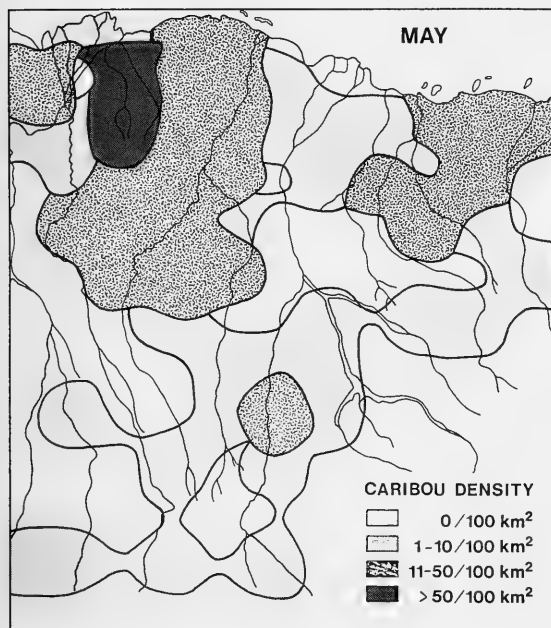


FIGURE 4. Average Caribou density in the Central Arctic region in late May based on 1982 and 1983 surveys.

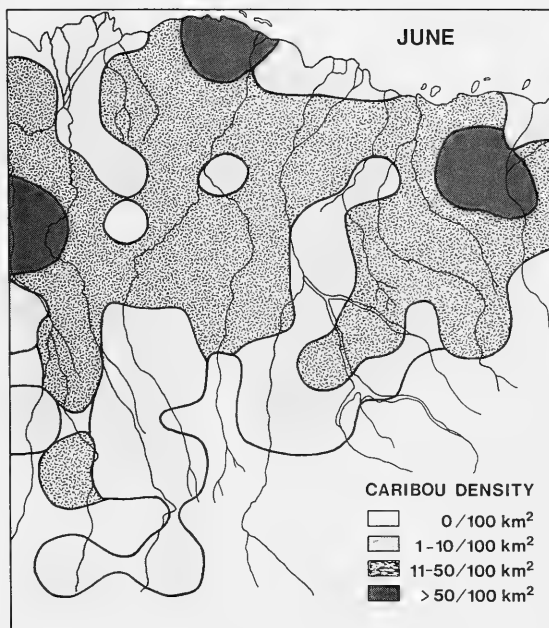


FIGURE 5. Average Caribou density in the Central Arctic region in mid-June based on surveys 1981 to 1983.

Itkillik River, along the Sagavanirktok River and north of the White Hills and Franklin Bluffs. Most of the area between the Itkillik and Kavik rivers up to 100 km south of the coast was occupied in all survey years.

Pre-Rut: By September, Caribou had begun moving into the southern foothills but most were still found in the central portions of the study area (Figure 9). High densities were found in the area between the Kuparuk and Itkillik rivers and between Franklin Bluffs and the Canning River. Both areas were consistently used during the three years of the study. High densities in the southwest were largely the result of an influx of Caribou from the west in mid-September of 1981 and 1982. This influx appeared to continue during the rut.

Rut: In October, Caribou were widely dispersed over the study area (Figure 10). In all years, the highest densities occurred from the Colville River delta southeast to Franklin Bluffs and thence northeast to the Canning River delta.

High densities of Caribou located west of the northern part of the Colville River in 1983 and in the southwest in 1981 and 1982 were likely the result of an influx of Western Arctic Caribou into the study area. On 9 October 1981 we observed 2500 Caribou west of

Galbraith Lake along the foothills. In October 1982 we estimated, based on 10% survey coverage, that 27 000 caribou were in the study area, with over a third of these located within the foothills. In 1981 and 1982 extensive trail systems indicated that Caribou had entered the study area from the northwest and were travelling through the foothills along river valleys in a southeasterly direction. In October 1983 an estimated 29 000 Caribou were in the study area, with the majority located north of the foothills. No specific movements into the study area were detected in 1983.

Discussion

The Central Arctic herd exhibits subtle annual shifts in distribution along a north-south axis. This observation is consistent with data presented by Gavin (1979) and Cameron and Whitten (1979). However, our study also indicates that pronounced changes in overall numbers and distribution may occur in the fall and winter due to an influx of Caribou from west of the study area.

Large numbers of Caribou from the Western Arctic herd have wintered in the study area in the past. During the winter of 1958, about 150 000 Caribou were reported in the Central Arctic region, including

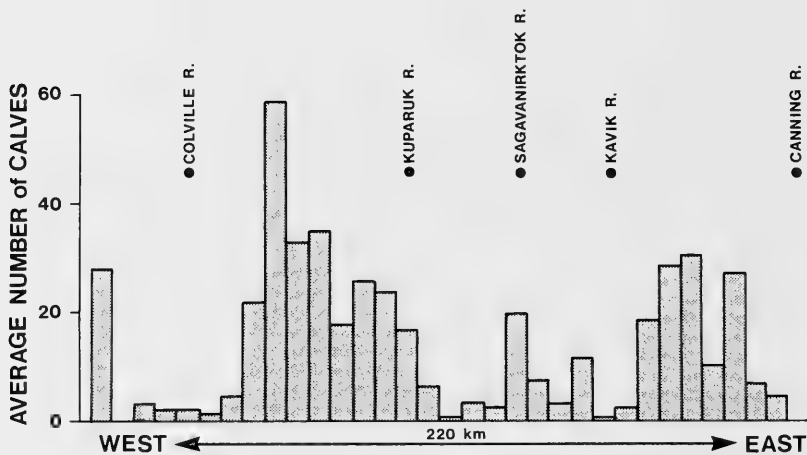


FIGURE 6. Distribution of calves from east to west across the study area in mid-June, average 1981-1983.

the western half of our study area (S. T. Olson. 1959. Movements, distribution and numbers — Arctic caribou and other herds. Unpublished report by the U.S. Fish and Wildlife Service, Anchorage, Alaska). Skoog's (1968: 261) historical review described a "large wintering concentration . . . along the foothills between the Kuparuk and central Colville Rivers" in the 1930s. During the last decade, use of western portions of the study area by the Western Arctic herd during winter has been increasing (P. Valkenburg, J. L. Davis, and P. F. Karcznarczyk. 1983. Historical movements and distribution of the Western Arctic caribou herd — an overview, 1983. Unpublished report by the Alaska Department of Fish and Game, Fairbanks, Alaska).

During this study, a few hundred Caribou wintered on the coastal plain as has been reported in the past (Roseneau et al. 1975; Gavin 1979). However, the main winter distribution was closer to the mountains than the coastal plain, as was reported by Roseneau et al. (1975) during 1974.

During 1969 and the early 1970s, when at least 26 000 caribou were reported in the study area (Gavin 1979), winter distribution may have included areas south of the Brooks Range (Gavin 1975, 1979). At that time Hemming (1971), Gavin (1975, 1979) and Roseneau and Stern (1974) described movements of Caribou in the spring and fall through the Brooks Range by means of passes associated with the Anaktuvuk, Atigun, Itkillik, Sagavanirktok and Canning rivers. By 1975, these movements and the numbers of Caribou involved had decreased from previous years (Roseneau et al. 1975; Gavin 1979).

Winter range overlap may also occur between the Central Arctic and Porcupine Caribou herds. Recent radio-telemetry studies of the winter distribution of the Porcupine herd as well as past reports show winter range occupancy in Alaska which extends into the southeastern part of the study area (Hemming 1971; Roseneau et al. 1974, 1975; Whitten et al. 1985a). In 1983-84 about 1000 Porcupine herd animals wintered in the Schrader Lake area on the North Slope in close proximity to Central Arctic herd animals. During spring migration, the Porcupine herd animals moved east, whereas Central Arctic herd animals moved west (Whitten et al. 1985b).

We observed movements along the Anaktuvuk, Itkillik and Atigun rivers in spring and fall. Although no surveys were flown south of the Brooks Range, no sign of wintering Caribou was noted during frequent ferry flights over the area. Caribou moved south to the headwaters of the Atigun River but returned to the foothills and moved west in October of each year of this study. In 1984 and 1985, Carruthers and Jakimchuk (1986) reported similar numbers of Caribou in the study area in February as in November, suggesting that migration out of the study area during winter did not occur.

The marked reduction from March to May in the density of Caribou found in the study area suggested a large movement out of the study area. This movement probably occurred in April and involved at least two-thirds of the animals in the region. Valkenburg et al. (1983) described historic movements by Western Arctic caribou from winter range in the southwest of the study area to the west. Gavin (1979) and Roseneau and Stern (1974) reported similar movements in 1972.

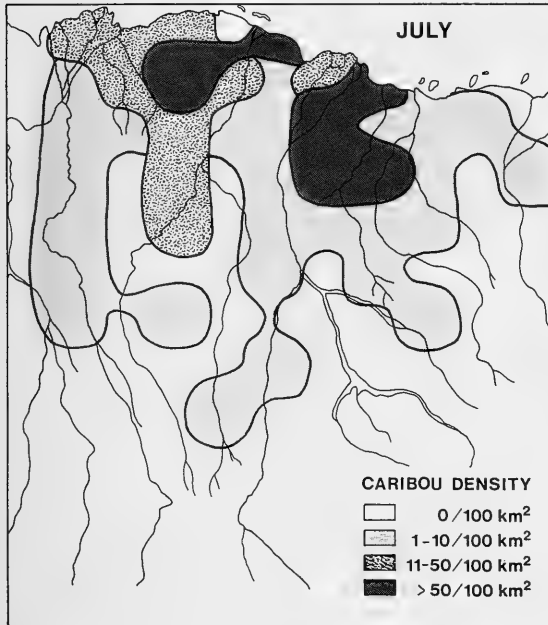


FIGURE 7. Average Caribou density in the Central Arctic region in mid-July based on surveys 1981 to 1983.

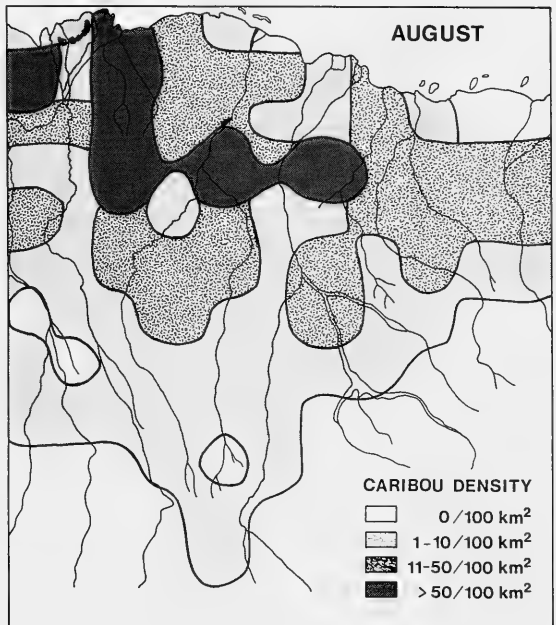


FIGURE 8. Average Caribou density in the Central Arctic region in mid-August based on surveys 1981 to 1983.

This westward movement may also have occurred in 1982, 1983 and 1984 (Carruthers and Jakimchuk 1986).

This study and Gavin (1979) reported consistent use of two main calving areas, except in 1971 and 1972 when snow delayed northward migration (Roseneau and Stern 1974). Gavin (1979) noted that calving also occurred elsewhere in the study area, including the White Hills and Franklin Bluffs, a distribution similar to that observed in this study during 1983 when snow delayed northward movement of parturient cows. Between 1969 and 1977, most (>80%) calves were observed east of the Sagavanirktok River (Gavin 1979). Subsequent work, however, indicates a more equal distribution of maternal females on either side of the Sagavanirktok River (Cameron et al. 1983; Lawhead and Curatolo 1984).

Overall, the work of Cameron and Whitten (1978), Gavin (1979), Cameron et al. (1983), Lawhead and Curatolo (1984) and this study show a general calving distribution, between the Colville and Canning rivers, which extends at least 100 km from the coast. As noted in previous years, the central area between the Kuparuk and Kavik rivers supports few Caribou near the coast, although higher densities occur farther inland around Franklin Bluffs (Roseneau et al. 1974; LeResche 1975; White et al. 1975; Cameron and

Whitten 1978; Gavin 1979; Lawhead and Curatolo 1984; Whitten and Cameron 1985). A low-density calving distribution was also characteristic near the Sagavanirktok and Colville rivers, which are in flood during the calving period and where large deltas are present. The most notable characteristic of calving Caribou was their preference for snow-covered lowlands or well-drained uplands rather than major river valleys or deltas.

Since at least 1969, the post-calving distribution of Caribou has been largely confined to the coast, where large aggregations of caribou (up to 3000 animals) were common during the mosquito season (Child 1973; White et al. 1975; Gavin 1979). This distribution and the movements of Caribou along the coast have occurred for many years, as indicated by the well-worn trails observed in this study and described by Child (1973), Roseneau and Stern (1974) and Gavin (1979).

Prior to 1975, Gavin (1979) reported up to 18 000 Caribou along the coast during July and August, with movements of large aggregations east and west. From 1972 to 1974, similar movements, some of which originated east of the Canning River, were reported by Roseneau et al. (1974) and Roseneau and Stern (1974). After 1975, Gavin (1979) reported much smaller aggregations and noted that the number of Caribou in the region was much lower than in the

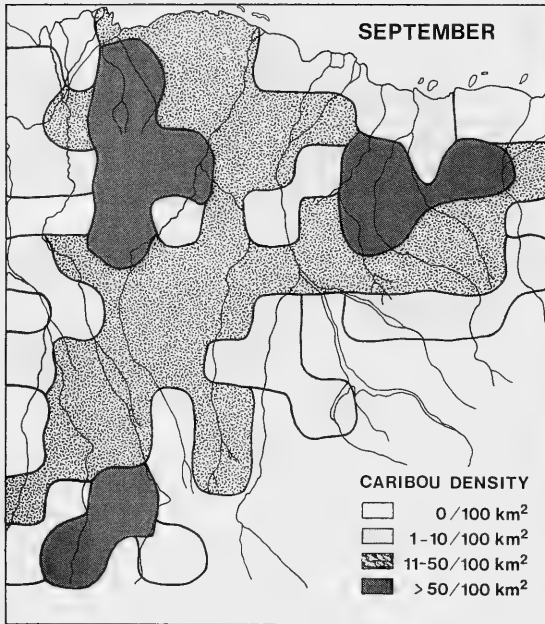


FIGURE 9. Average Caribou density in the Central Arctic region in mid-September based on surveys 1981 to 1983.

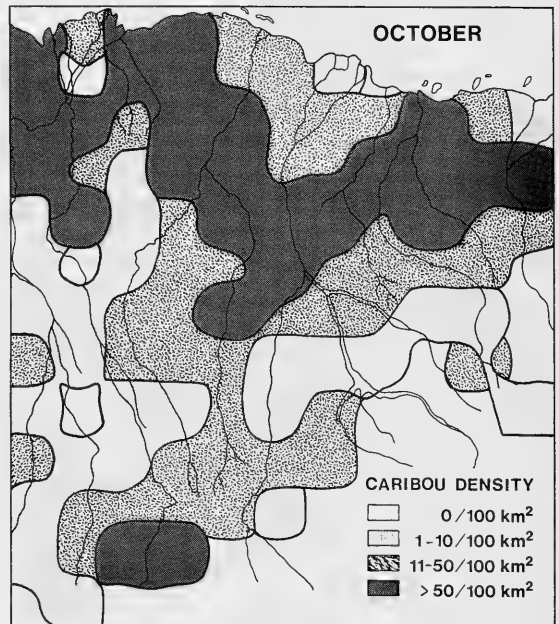


FIGURE 10. Average Caribou density in the Central Arctic region in mid-October based on surveys 1981 to 1983.

early 1970s. These lower numbers probably influenced the extent of aggregation and east-west movements.

In 1982 and 1983, when an estimated 9000 to 13 000 Caribou were in the study area in July (Whitten and Cameron 1983), the size of post-calving aggregations increased to pre-1975 levels (Fancy 1983; Lawhead and Curatolo 1984). The direction of movement of these aggregations changed frequently according to temperature and wind patterns and the resulting levels of mosquito activity. Generally, during periods of insect harassment, Caribou were found along the coast and on river deltas, whereas inland movements predominated during periods when insect activity was low (White et al. 1975; Lawhead and Curatolo 1984).

In the present study, large numbers of Caribou appeared to move into the study area during the fall. In October 1982 and 1983, 27 000–29 000 caribou were in the study area, compared to the 13 000 estimated for the Central Arctic herd in July 1983 (Whitten and Cameron 1983). Such movements could account for the large numbers of Caribou observed in the study area between 1950 and 1970. Trail systems observed in October 1982 suggest that these animals originated from the Western Arctic herd.

Previous influxes of Caribou in the Central Arctic region occurred most frequently and involved large numbers during the period when the Western Arctic and Porcupine herds were large (Skoog 1968; Roseneau and Stern 1974; Roseneau et al. 1974; Davis et al. 1980; Haber and Walters 1980). The Western Arctic herd declined sharply during the early 1970s (Davis et al. 1980) and as it declined, the numbers of Caribou in the Central Arctic region also declined (Cameron and Whitten 1980; Gavin 1979). Since 1976, both the Western and Central Arctic herds have increased in size (Davis et al. 1980; Whitten and Cameron 1983), and large numbers of Caribou are appearing in the Central Arctic region as they have in the past.

Recent estimates suggest that the Porcupine herd is increasing after 20 years of stability (Whitten 1984). If the herd continues to grow, Caribou from this herd may again move into the Central Arctic region.

Although the distribution of Caribou in the Central Arctic region has remained relatively consistent in recent years, the number of Caribou using the region during the fall and winter has increased markedly. This seasonal variation in numbers appears to be a result of the annual ingress and egress of animals from adjacent herds. Skoog (1968) and Hemming (1971)

viewed the region as a peripheral zone occupied by Western Arctic and Porcupine Caribou when their numbers were large. This view is consistent with our observations over a three-year period. Our data indicate that a resident herd of Caribou remains in the study area year-round and calves along the coastal plain. This herd numbered about 13 000 in July 1983 (Whitten and Cameron 1983). However, movement into the region by immigrant Caribou occurs during the fall. The numbers of Caribou using the region vary according to the growth or decline of the adjacent Western Arctic and Porcupine Caribou herds.

There are several implications of the dynamic nature of Caribou use of the Central Arctic region. For example, considerable attention has been focussed on the Central Arctic herd over the last decade as a result of its proximity to TAPS and expanding petroleum development within its home range. Any interpretations of the effects of oil development on Caribou must recognize the complex relationship between the resident population and adjacent herds, and the corresponding population fluctuations which result. Census data and the timing of censuses must also recognize the considerable seasonal variation in Caribou numbers in the region. Finally, the foregoing considerations have obvious applicability to management decisions pertaining to harvest levels and bag limits of Caribou in the Central Arctic region.

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Literature Cited

- Benson, C., R. Timmer, B. Holmgren, G. Weller, and S. Parrish. 1975. Observations on the seasonal snow cover and radiation climate at Prudhoe Bay, Alaska, during 1972. Biological Papers, University of Alaska, Fairbanks, Alaska. Special Report 2: 13-52.
- Bergerud, A. T., R. D. Jakimchuk, and D. R. Carruthers. 1984. The buffalo of the north: caribou (*Rangifer tarandus*) and human developments. Arctic 37(1): 7-22.
- Cameron, R. D., and K. R. Whitten. 1978. Third interim report of the effects of the Trans-Alaska Pipeline on caribou movements. Joint State/Federal Wildlife Advisory Team, Alaska Department of Fish and Game. Special Report No. 22.
- Cameron, R. D., and K. R. Whitten. 1979. Seasonal movements and sexual segregation of caribou determined by aerial survey. Journal of Wildlife Management 43: 626-633.
- Cameron, R. D., and K. R. Whitten. 1980. Influence of the Trans-Alaska Pipeline corridor on the local distribution of caribou. Pp. 475-481 in Proceedings of the Second Reindeer/Caribou Symposium. Edited by E. Reimers, E. Gaare, and S. Skjenneberg. Direktoratet for Vilt og Ferskvannsfisk, Trondheim, Norway.
- Cameron, R. D., K. R. Whitten, and W. T. Smith. 1983. Responses of caribou to petroleum-related development in Alaska's arctic slope. Alaska Department of Fish & Game Progress Report. Federal Aid in Wildlife Restoration, Project W-21-2 and W-22-1, Job 3.18R. 75 pp.
- Carruthers, D. R., and R. D. Jakimchuk. 1986. Caribou of the central arctic region of Alaska in relation to adjacent caribou herds. Rangifer, Special Issue Number 1: 65-71.
- Caughley, G. 1977. Sampling in aerial survey. Journal of Wildlife Management 41(4): 604-615.
- Child, K. N. 1973. The reactions of barren-ground caribou (*Rangifer tarandus granti*) to simulated pipeline and pipeline crossing structures at Prudhoe Bay, Alaska. Completion report, Alaska Cooperative Wildlife Research Unit, University of Alaska, Fairbanks, Alaska. 45 pp.
- Davis J. L., P. Valkenburg, and H. V. Reynolds. 1980. Population dynamics of Alaska's Western Arctic caribou herd. Pp. 595-604 in Proceedings of the Second International Reindeer/Caribou Symposium. Edited by E. Reimers, E. Gaare, and S. Skjenneberg. Direktoratet for Vilt og Ferskvannsfisk, Trondheim, Norway.
- Eberhardt, L. L. 1981. Comments on transect methodology. Pp. 17-39 in Symposium on census and inventory methods for populations and habitats. Edited by F. L. Miller and A. Gunn. Forestry and Wildlife Range Experiment Station, University of Idaho, Moscow, Idaho.
- Fancy, S. G. 1983. Movements and activity budgets of caribou near oil drilling sites in the Sagavanirktok River floodplain, Alaska. Arctic 36(2): 193-197.
- Gavin, A. 1975. Weather and its effect on caribou behavior patterns and migrations. Pp. 414-419 in Proceedings of the first international reindeer and caribou symposium. Edited by J. R. Luick, P. C. Lent, D. R. Klein, and R. G. White. Biological Papers, University of Alaska, Fairbanks, Alaska. Special Report Number 1.
- Gavin, A. 1979. Wildlife on the North Slope: a ten year study 1969-1978. Published by ARCO Alaska, Inc., Anchorage, Alaska. 46 pp.
- Haber, G. C., and C. J. Walters. 1980. Dynamics of the Alaska-Yukon caribou herds and management implications. Pp. 624-2644 in Proceedings of the second international reindeer/caribou symposium. Edited by E. Reimers, E. Gaare, and S. Skjenneberg. Direktoratet For Vilt og Ferskvannsfisk, Trondheim, Norway.
- Hemming, J. E. 1971. The distribution and movement patterns of caribou in Alaska. Alaska Department of Fish and Game, Technical Bulletin Number 1. 60 pp.
- Kelsall, J. P. 1968. The migratory barren-ground caribou of Canada. Canadian Wildlife Service Monograph Number 3. Queen's Printer, Ottawa. 340 pp.

- Lawhead, B. E., and J. A. Curatolo.** 1984. Distribution and movements of the Central Arctic caribou herd, summer 1983. Prepared for ARCO Alaska Inc. by Alaska Biological Research. 52 pp.
- LeResche, R. E.** 1975. The international herds: present knowledge of the Fortymile and Porcupine herds. Pp. 127-139 in *Proceedings of the first reindeer/caribou symposium. Edited by J. R. Luick, P. C. Lent, D. R. Klein, and R. G. White.* Biological Papers, University of Alaska, Fairbanks, Alaska. Special Report Number 1, 1975.
- Roseneau, D. G., and P. Stern.** 1974. Distribution and movements of the Porcupine caribou herd in northeastern Alaska, 1972. Arctic Gas Biological Report Series Volume 7. 209 pp.
- Roseneau, D. G., P. Stern, and C. Warbelow.** 1974. Distribution and movements of the Porcupine caribou herd in northeastern Alaska. Arctic Gas Biological Report Series Volume 22. 197 pp.
- Roseneau, D. G., J. Curatolo, and G. Moore.** 1975. The distribution and movements of the Porcupine caribou herd in northeastern Alaska and the Yukon Territory, 1974. Arctic Gas Biological Report Series Volume 32. 104 pp.
- Selkregg, L. L.** 1975. Alaska regional profiles, Arctic region. Volume II. Arctic Environment Information and Data Center. University of Alaska, Anchorage, Alaska. 218 pp.
- Skoog, R. D.** 1968. Ecology of caribou (*Rangifer tarandus granti*) in Alaska. Ph.D. thesis, University of California, Berkeley, California. 699 pp.
- Spetzman, L. A.** 1959. Vegetation of the arctic slope of Alaska. U.S. Geological Survey Professional Paper 302-B. U.S. Government Printer's Office, Washington, D.C. 58 pp.
- Wahrhaftig, C.** 1965. Physiographic divisions of Alaska. U.S. Geological Survey Professional Paper 482. 52 pp.
- White, R. G., B. R. Thomson, T. Skogland, S. J. Pearson, D. E. Russell, D. F. Holleman, and J. R. Luick.** 1975. Ecology of caribou at Prudhoe Bay, Alaska. Pp. 151-187 in *Ecological investigations of the Tundra Biome in the Prudhoe Bay Region, Alaska.* Biological Papers, University of Alaska, Fairbanks, Alaska. Special Report Number 2.
- Whitten, K. R.** 1984. Survey-inventory progress report — Porcupine. Pp. 53-56 in *Annual report of survey-inventory activities. Part VI. Caribou. Volume XIV.* Edited by J. A. Barnett. Alaska Department of Fish and Game, Federal Aid in Wildlife Restoration Project W-22-1, Job 3.0, Juneau, Alaska.
- Whitten, K. R., and R. D. Cameron.** 1983. Population dynamics of the Central Arctic herd, 1975-1981. *Acta Zoologica Fennica* 175: 159-161.
- Whitten, K. R., and R. D. Cameron.** 1985. Distribution of caribou calving in relation to the Prudhoe Bay oilfield. Pp. 35-39 in *Caribou and human activity. Proceedings of the first North American Caribou Workshop, Whitehorse, Yukon.* Edited by A. M. Martell and D. E. Russell. Canadian Wildlife Service Special Publication, Ottawa.
- Whitten, K. R., F. J. Mauer, G. W. Garner, and D. E. Russell.** 1985a. Fall and winter movements and distribution and annual mortality patterns of the Porcupine caribou herd, 1983-1984. ANWR Progress Report No. FY85-17. Alaska Department of Fish and Game, Fairbanks, Alaska.
- Whitten, K. R., F. J. Mauer, G. W. Garner, and D. E. Russell.** 1985b. Calving distribution, initial productivity, and neonatal mortality of the Porcupine caribou herd, 1984. ANWR Progress Report No. FY85-18. Alaska Department of Fish and Game, Fairbanks, Alaska.

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Notes

Nest Appropriation and Interspecific Feeding between Tree Swallows, *Tachycineta bicolor*, and Barn Swallows, *Hirundo rustica*

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Butler, Robert W., and Carol A. Campbell. 1987. Nest appropriation and interspecific feeding between Tree Swallows, *Tachycineta bicolor*, and Barn Swallows, *Hirundo rustica*. Canadian Field-Naturalist 101(1): 433-434.

A pair of Tree Swallows (*Tachycineta bicolor*) evicted a pair of nest building Barn Swallows (*Hirundo rustica*) and fledged one Tree Swallow from the nest. The Barn Swallows renested 1.6 m away and fed the fledgling Tree Swallow when it temporarily moved from the first to the second nest. Thus, Tree Swallows can use alternate sites when typical nest holes are unavailable and Barn Swallows do not always discriminate between foreign and their own young for a substantial part of the nestling period.

Key Words: Tree Swallow *Tachycineta bicolor*, Barn Swallow *Hirundo rustica*, nest appropriation, interspecific feeding.

Among birds, reuse of nests is widespread and generally occurs when the owner abandons the site (Butler 1980). Tree Swallows (*Tachycineta bicolor*) are known to place nesting materials over Bufflehead (*Bucephala albeola*) eggs and European Starlings (*Sturnus vulgaris*) eject the eggs of Northern Flickers (*Colaptes auratus*) while usurping the nest site (Erskine 1971). The Chestnut Sparrow (*Passer eminibey*) no longer builds a nest but evicts others (Payne 1969). Erskine (1979) described the Tree Swallow as an obligate hole-nester because they nest elsewhere relatively rarely. We can find no published records of a Tree Swallow nesting in a Barn Swallow (*Hirundo rustica*) nest although there is one record in the British Columbia Nest Record Scheme for Naramata. The purpose of this note is to document one case of Tree Swallows evicting Barn Swallows from a nest and subsequent feeding of a fledgling Tree Swallow by the same pair of Barn Swallows at their second nest.

In late May 1982 a pair of Barn Swallows built a nest on the outside wall of the Creston Valley Wildlife Interpretation Centre, 10 km west of Creston, British Columbia. The mud cup was nearly complete on 3 June when a pair of Tree Swallows began to perch on a pipe within 0.5 m of the Barn Swallow nest. The two species alternated visits to the nest: the Tree Swallows carried feathers and grass to line the nest and the Barn Swallows brought mud for the nest rim. By 8 June the Tree Swallows had taken sole possession of the nest and laid the first of five eggs.

Meanwhile the Barn Swallows began to build a second nest on top of a sign 1.6 m along the same wall

and at the same height (1.6 m) as their original nest. They laid the first of five eggs on 14 June. No interspecific aggression was seen; however, our observations were discontinuous.

The Tree Swallows hatched on 25 June. Two nestlings fell from the nest overnight on 29-30 June and 30 June-1 July, respectively. A third and fourth nestling were missing on 2 and 3 July, respectively. The surviving fledgling left the nest during the second week of July. On 14 July, a Tree Swallow fledgling, presumably the one raised nearby, settled into the second nest built by the Barn Swallows whose four nestlings were 14 days old. The fledgling spent periods of 11, 11, and 15 mins in the nest during 09:58-10:58, and was fed on 11 of 31 visits by the adult Barn Swallows.

A shortage of Tree Swallow nest sites and a willingness by the Barn Swallows to relocate may have allowed for usurpation of the site. A pair of Tree Swallows nested annually for at least five years in a hole in a railing about 4 m from the usurped Barn Swallow nest. That railing was removed in 1981. Barn Swallows built nests in the original site and moved to the second site when the first nest was destroyed, in at least the previous two years. We suggest that Tree Swallows are adaptable in their choice of nest sites because they are unable to excavate nest holes.

Parent-offspring recognition in colonial nesting birds occurs shortly before families intermingle (Tinbergen 1953; Cullen 1957; Beecher et al. 1981). Barn Swallows generally nest as solitary pairs or in loose colonies. Grzybowski (1979) showed experi-

mentally that Barn Swallows could not distinguish between their own young up to 11 days of age and Burtt (1977) showed that Barn Swallows do not start to recognize their young until the time of fledging. Furthermore, Barn Swallows have been reported to feed unrelated fledgling Barn Swallows that settle in their nests (Ball 1982). Our data suggest that adult Barn Swallows also do not recognize young of alien species during at least part of the nestling period.

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Literature Cited

- Ball, G. 1982. Barn Swallow fledgling successfully elicits feeding at a non-parental nest. *Wilson Bulletin* 94: 362–363.
- Beecher, M. D., I. M. Beecher, and S. Hahn. 1981. Parent-offspring recognition in Bank Swallows (*Riparia riparia*): II. Development and acoustic basis. *Animal Behaviour* 29: 95–101.

- Burtt, E. H., Jr. 1977. Some factors in the timing of parent-chick recognition in swallows. *Animal Behaviour* 25: 231–239.
- Butler, R. W. 1980. Appropriation of an American Robin nest by Dark-eyed Juncos. *Canadian Field-Naturalist* 94: 197.
- Cullen, R. 1957. Adaptations in the Kittiwake to cliff nesting. *Ibis* 99: 275–302.
- Erskine, A. J. 1971. Buffleheads. *Canadian Wildlife Service Monograph Series Number 4*. Ottawa. 240 pp.
- Erskine, A. J. 1979. Man's influence on potential nesting sites and populations of swallows in Canada. *Canadian Field-Naturalist* 93: 371–377.
- Grzybowski, J. A. 1979. Responses of Barn Swallows to eggs, young, nests, and nest sites. *Condor* 81: 236–246.
- Payne, R. B. 1969. Nest parasitism and display of Chestnut Sparrows in a colony of Gray-capped Social Weavers. *Ibis* 111: 300–307.
- Timbergen, N. 1953. *The Herring Gull's world*. Collins, London.

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Evidence for the Requirement of Sperm in Unisexual Salamander Hybrids (Genus *Ambystoma*)

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Bogart, James P., and Lawrence E. Licht. 1987. Evidence for the requirement of sperm in unisexual salamander hybrids (genus *Ambystoma*). *Canadian Field-Naturalist* 101(3): 434–436.

A fast and easy method is described which can be used to detect insemination in hybrid female salamanders of the genus *Ambystoma*. Finding sperm in the cloacae of these females provides evidence of the presence of males, which are often rare. Of 70 females examined on Pelee Island, only those females which were found to be sperm positive gave rise to free-swimming larvae. It is suggested that true parthenogenesis does not occur in the sampled populations.

Key Words: Amphibia, Caudata, *Ambystoma*, hybrids, sperm, parthenogenesis, *Ambystoma laterale*, Blue-spotted Salamander, *Ambystoma texanum*, Smallmouth Salamander.

Unisexual hybrids of mole salamanders, *Ambystoma*, occur in the Great Lakes region of eastern North America. Hybridization has occurred between *A. jeffersonianum* (Jefferson Salamander) and *A. laterale* (Blue-spotted Salamander) to produce the triploids, "*A. platineum*" and "*A. tremblayi*" (Uzzell 1963, 1964); between *A. laterale* and *A. texanum* (Smallmouth Salamander) to produce diploid and polyploid hybrids (Downs 1978; Kraus

1985a; Bogart et al. 1985; Bogart and Licht 1986); between *A. laterale*, *A. texanum* and *A. tigrinum* (Tiger Salamander) to produce the triploid trihybrid "*A. nothogenes*" (Kraus 1985b).

Owing to the continued existence of these hybrids, and the fact that they are essentially all-female, it has been hypothesized that they reproduce either by parthenogenesis (Uzzell 1969; Downs 1978; Kraus 1985a, 1985b), a mode in which sperm is not necessary

at all, or by gynogenesis (Uzzell 1964; Macgregor and Uzzell 1964; Morris and Brandon 1984), in which sperm from a male is used for initiation of cleavage. The male is presumed to be from a sympatric, normally bisexually reproducing species. In gynogenesis, the male genome is not incorporated into the egg nucleus and this mode may also be considered as a form of parthenogenesis (Lynch 1984; Moore 1984).

In a study of *Ambystoma* egg masses in Ontario, Bogart (1982) found some egg masses which had mixed genotypes and ploidy ($2n$ and $3n$). This suggests that certain females are neither parthenogenetic nor gynogenetic. But, in the same study, a single female was found to produce 28 larvae which were genetically identical for two polymorphic electrophoretic loci. This female's cloaca did contain sperm and, based on the available information, reproduction by gynogenesis remains a possibility. True parthenogenesis, without sperm to initiate development, has yet to be proven for any population of *Ambystoma*.

We have been studying *A. laterale* x *A. texanum* hybrids on Pelee Island in Lake Erie, Ontario ($41^{\circ}45'N$, $82^{\circ}40'W$), where males are rare (less than 5%; Bogart et al. 1985). It was deemed important to determine the presence or absence of sperm in the reproductive tract of these females and to examine a large number of females. Such information is essential to distinguish between true parthenogenesis and gynogenesis, as well as being a first step toward elucidating alternative mechanisms. The following procedure allows for the detection of sperm from females taken from breeding populations.

Females were removed from breeding ponds on Pelee Island and maintained at $8^{\circ}C$ while transported to the laboratory. They were anesthetized in tricaine methane sulfonate (MS222), after which a small drop of physiological saline solution was inserted into the cloaca with a Pasteur pipette. The cloaca was flushed using gentle pressure on the bulb of the pipette. A drop of the cloacal fluid was placed on a slide and a cover slip applied to the wet mount. The slide was examined for the presence of sperm using phase contrast optics under low power (16X objective: total magnification 160X).

Ambystoma sperm cells are large and easily observed under low power so the entire slide can be scanned before they die. The activity of the sperm cells makes it relatively easy to observe and photograph them (Bogart 1982). The technique is rapid and it is possible to examine a large number of females in a short period of time.

We used this technique to determine the presence or absence of sperm in the cloacae of 70 Pelee Island female *A. laterale* x *A. texanum* hybrids. Of these, 23 were found to be sperm negative and all others had

observable sperm. Sperm was observed from females prior to egg deposition as well as after the eggs had been deposited. Females maintained for up to two weeks at $8^{\circ}C$ after being removed from the breeding population still contained viable sperm. Post-ovulatory females kept at room temperature for two weeks or under refrigeration for longer periods of time (three weeks) showed no evidence of sperm even though some of these same females were sperm-positive in earlier examinations.

Of the initial 70 females examined, only the 47 sperm-positive females laid eggs which either showed late embryological stages or hatched. None of the sperm negative females produced eggs which hatched. We therefore suggest that sperm is essential for normal egg development among Pelee Island *Ambystoma* hybrids. We have observed sperm in females from breeding ponds where males have not yet been found. We also have evidence from the electrophoretic analyses of females and their offspring that genes from sperm are actually present in the zygotes, and this evidence suggests that neither parthenogenesis nor obligatory gynogenesis is operating on Pelee Island (Bogart and Licht 1986).

Survival time for spermatozoa varies in salamanders from a few weeks to more than two years (Boisseau and Joly 1975). Sperm survival in one species of *Ambystoma* (*A. opacum*) is at the low end of the range (Noble and Brady 1933). In his investigation of salamander breeding behaviour, Arnold (1976) examined the cloacae of *A. maculatum* and *A. tigrinum* and observed spermatophores which had just been deposited by males and retrieved by females during laboratory breeding trials. Arnold, however, did not describe his technique for the examination of the females nor did he look for actual spermatozoa.

Noble (1931) suggested that fertilization in salamanders occurs in oviducts, but more recent evidence (Boisseau and Joly 1975; Sever and Houck 1985) indicates that spermatozoa are extruded onto eggs in the cloaca just before they are laid and thus, spermatozoa may not be expected to occur in oviducts. In fact, the ascent of sperm into the oviduct of salamanders is only known to occur in the viviparous *Salamandra salamandra* (Boisseau and Joly 1975). This may explain the findings of Cuellar (1976) who, in his study of meiosis in triploid "*A. tremblayi*," did not examine the cloaca but noted the absence of sperm in oviducts and suggested the possibility of parthenogenesis.

An examination for sperm in the cloacae of breeding females of unisexual *Ambystoma* populations has only been described previously for one individual of the *Ambystoma jeffersonianum*

complex (Bogart 1982). In some other populations it was observed that spermatophores were needed for females to produce normal eggs (Wilber 1971). Using the technique of rapid detection of sperm in the cloacae of females described here, the presence or absence of males and the possible role of males in reproduction may be assessed. A determination of sperm dependency should help clarify the breeding systems used by the different populations of unisexual *Ambystoma* throughout their ranges.

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Literature Cited

- Arnold, Steven J.** 1976. Sexual behavior, sexual interference, and sexual defense in the salamanders *Ambystoma maculatum*, *Ambystoma tigrinum* and *Plethodon jordani*. *Zeitschrift Tierpsychologisch* 42: 247-300.
- Bogart, J. P.** 1982. Ploidy and genetic diversity in Ontario salamanders of the *Ambystoma jeffersonianum* complex revealed through an electrophoretic examination of larvae. *Canadian Journal of Zoology* 60: 848-855.
- Bogart, J. P., L. E. Licht, M. J. Oldham, and S. J. Darbyshire.** 1985. Electrophoretic identification of *Ambystoma laterale* and *Ambystoma texanum* as well as their diploid and triploid interspecific hybrids (Amphibia: Caudata) on Pelee Island, Ontario. *Canadian Journal of Zoology* 63: 340-347.
- Bogart, J. P., and L. E. Licht.** 1986. Reproduction and the origin of polyploids in hybrid salamanders of the genus *Ambystoma*. *Canadian Journal of Genetics and Cytology* 28: 605-617.
- Boisseau, C., and J. Joly.** 1975. Transport and survival of spermatozoa in female Amphibia. Pages 94-104 in *The biology of spermatozoa*. Edited by E. S. E. Hafez and C. G. Thibault. Proceedings of the INSERM International Symposium, Nouzilly (1973). S. Karger, Basel, New York.
- Cuellar, O.** 1976. Cytology of meiosis in the diploid gynogenetic salamander *Ambystoma tremblayi*. *Chromosoma* (Berlin) 58: 355-364.
- Downs, F. L.** 1978. Unisexual *Ambystoma* from the Bass Islands of Lake Erie. Occasional Paper, Museum of Zoology, University of Michigan (685): 1-36.
- Kraus, F.** 1985a. A new unisexual salamander from Ohio. Occasional Papers, Museum of Zoology, University of Michigan (709): 1-24.
- Kraus, F.** 1985b. Unisexual salamander lineages in northwestern Ohio and southwestern Michigan: a study of the consequences of hybridization. *Copeia* 1985: 309-324.
- Lynch, M.** 1984. Destabilizing hybridization, general-purpose genotypes and geographic parthenogenesis. *Quarterly Review of Biology* 59: 257-290.
- Macgregor, H. C., and T. M. Uzzell, Jr.** 1964. Gynogenesis in salamanders related to *Ambystoma jeffersonianum*. *Science* 143: 1043-1045.
- Moore, W. S.** 1984. Evolutionary ecology of unisexual fishes. Pages 329-398 in *Evolutionary genetics of fishes*. Edited by B. J. Turner. Plenum Publishing Corporation.
- Morris, M. A., and R. A. Brandon.** 1984. Gynogenesis and hybridization between *Ambystoma platineum* and *Ambystoma texanum* in Illinois. *Copeia* 1984: 324-337.
- Noble, G. K.** 1931. The biology of the amphibia. McGraw-Hill Book Co., New York.
- Noble, G. K., and M. K. Brady.** 1933. Observations on the life history of the marbled salamander, *Ambystoma opacum* Gravenhorst. *Zoologica* 8: 89-132.
- Sever, D. M., and L. D. Houck.** 1985. Spermatophore formation in *Desmognathus ochrophaeus* (Amphibia: Plethodontidae). *Copeia* 1985: 394-402.
- Uzzell, T. M., Jr.** 1963. Natural triploidy in salamanders related to *Ambystoma jeffersonianum*. *Science* 139: 113-115.
- Uzzell, T. M., Jr.** 1964. Relations of the triploid and diploid species of the *Ambystoma jeffersonianum* complex (Amphibia: Caudata). *Copeia* 1964: 257-300.
- Uzzell, T. M.** 1969. Notes on spermatophore production by salamanders of the *Ambystoma jeffersonianum* complex. *Copeia* 1969: 602-612.
- Wilber, H. M.** 1971. The ecological relationship of the salamander *Ambystoma laterale* to its all-female, gynogenetic associate. *Evolution* 25: 168-179.

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New and Significant Vascular Plant Records for Manitoba

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Catling, P. M., and V. R. Brownell. 1987. New and significant vascular plant records for Manitoba. *Canadian Field-Naturalist* 101(3): 437-439.

Platanthera praeclara (Western Prairie Fringed Orchid) and *Juncus interior* (Inland Rush) are reported for the first time from Manitoba, the former record also being the first for Canada. The presence of *Platanthera* (*Habenaria*) *psycodes* (Purple Fringed Orchid) in the southeast corner of the province is confirmed. A second region of occurrence is reported for *Wolffia columbiana* (Water-meal) and additional stations of *Lysimachia quadriflora* (Four-flowered Loosestrife) are reported. The known range of a rare grass *Panicum wilcoxianum* var. *breitungii* is extended within the province to the east.

Key Words: Juncaceae, Lemnaceae, Primulaceae, Poaceae, Orchidaceae, *Juncus interior*, *Wolffia columbiana*, *Lysimachia quadriflora*, *Panicum wilcoxianum* var. *breitungii*, *Platanthera praeclara*, *Platanthera* (*Habenaria*) *psycodes*, range extensions, phytogeography, floristics, Manitoba, Canada.

The most detailed treatment of the vascular plants of Manitoba is that of Scoggan (1957), but other more recent texts include Manitoba (e.g. Boivin 1966-67, 1967-72, 1981; Looman and Best 1979; Scoggan 1978-79). These and other works (e.g. Ritchie 1956; Love and Bernard 1959; Looman 1969, 1973; Cody and Krivda 1974; Cody and Lafontaine 1975; Cody 1980) have included additions to Scoggan's 1957 publication. White and Johnson (1980) have recently discussed and mapped the rare species of Manitoba, but they noted that parts of the province have been inadequately explored and that critical study is needed in certain groups. As a consequence of both field work in southern Manitoba in late July and early August 1984, and study of herbarium specimens, several new and significant vascular plant records have come to light. These are discussed below.

Panicum wilcoxianum Vasey var. *breitungii* Boivin

This grass, which is rare in Manitoba (White and Johnson 1980) was found on a steep, west facing prairie slope with *Stipa spartea* Trin. var. *curtiseta* Hitchc. (a grass) and *Carex eleocharis* Bailey (a sedge), on the east side of the Pembina River valley (UTM 62 G/1 534311, 28 July 1984, P. M. Catling 84-117a and V. R. Brownell, DAO, MMMN). This station represents an isolated eastern extension of its range in Manitoba (cf. White and Johnson 1980; Boivin 1981).

Wolffia columbiana Karsten

Water-meal was found in association with other duckweeds (*Lemna turionifera* Landolt, *Lemna trisulca* L. and *Spirodela polyrrhiza* (L.) Schleid.) in a small bay at the north end of Lake Stormon (49°00'N, 100°04'W, International Peace Garden, ca. 26 km south of Boissevain, 29 July 1984, P. M. Catling 84-128 and V. R. Brownell, DAO, MMMN). This

location on Turtle Mountain represents a second region of occurrence, the plant being previously known in Manitoba only from the Riding Mountain National Park (Cody 1980).

Juncus interior Wieg.

Specimens from Sainte Agathe (49°34'N, 97°11'W, bord du chemin, 13 July 1953, J. P. Bernard 175, DAO) and Souris River (29 July 1883, J. M. Macoun, CAN 10228) are both clearly referable to this species, and they represent the first records for Manitoba.

Juncus interior (Inland Rush) is often confused with *Juncus dudleyi* Wieg. (Dudley's Rush), as was the case with the specimens cited above, and *Juncus tenuis* Willd. (Slender Rush). From these it differs in having a membranous (i.e. neither scarious nor cartilaginous) auricles, and perianth 3-4 mm long, more or less equalling the capsule (Wiegand 1900; Rydberg 1932). It differs from other Manitoba *Juncus* spp. in the combination of flowers subtended by two small opposite bracteoles and flat leaves which are basal only.

A plant of the upper Mississippi valley and western prairie region, *J. interior* reaches its northeastern limit in the Quetico-Rainy Lake-Lake of the Woods area of Ontario (Riley and Walshe 1985), and at the sites reported above in Manitoba. In Ontario it occurs on rocky shorelines, and in the western prairies of the United States it occurs in low open prairie and about margins of sloughs.

Platanthera praeclara Sheviak and Bowles

Approximately 500 plants (both flowering and non-flowering) of the Western Prairie Fringed Orchid were found in the roadside ditches and adjacent natural prairies (Figure 1A) approximately 5 km west of Vita along highway 201 and east of the Gardenton road (26 July 1984, P. M. Catling 84-89 and V. R. Brownell,



FIGURE 1. A: Tall grass prairie habitat of *Platanthera praeclara* near Vita, southeastern Manitoba, dominated by *Andropogon gerardii* and *Sporobolus heterolepis*, B: Flower of *P. praeclara* from the Vita prairie viewed from the front.

DAO, MMMN, NYS). Vascular plant associates included various grasses, sedges and rushes (in approximate order of importance): *Andropogon gerardii* Vitman; *Sporobolus heterolepis* (Gray) Gray, *Deschampsia caespitosa* (L.) Beauv., *Agrostis stolonifera* L., *Eleocharis elliptica* Kunth, *Carex crawei* Dewey, *Dichanthelium acuminatum* (Swartz) Gould and Clark, *Juncus alpinus* Vill., *Carex praegracilis* W. Boott, *Betula glandulosa* Michx. (Dwarf Birch), and *Muhlenbergia richardsonis* (Trin.) Rydb.

This discovery was initially reported as *P. leucophaea* (Nutt.) Lindley (Johnson 1985), but the western plants previously referred to *P. leucophaea* have recently (Sheviak and Bowles 1986) been segregated as *P. praeclara*, the Western Prairie Fringed Orchid. This represents the first record of *P. praeclara* in Manitoba and in Canada. It is also the northernmost station in North America, separated by 161 km from the nearest station in Minnesota (cf. Sheviak and Bowles 1986). The distinctive column with anthers widely separated at the base is illustrated in Figure 18B.

Platanthera psycodes (L.) Lindley

Approximately 100 plants of Purple Fringed Orchid were found in moist open ground with *Calamagrostis canadensis* (Michx.) Beauv. (Canada Bluejoint), *Carex lasiocarpa* Ehrh. (a sedge), *Cornus stolonifera* Michx. (Red Osier Dogwood), and in an adjacent Ash (*Fraxinus* spp.) swamp, on the Buffalo Point Road approximately 2 km west of Shore Road, Buffalo Point, Lake of the Woods (26 July 1984, *P. M. Catling* 84-78 and *V. R. Brownell* DAO, MMMN).

The occurrence of this species in Manitoba was previously in question (Scoggan 1957: 221; 1978: 537).

Lysimachia quadriflora Sims.

Four-flowered Loosestripe is common in the region of Vita and Stuartburn (5 miles W of Vita, 26 July 1984, *P. M. Catling* 84-111a and *V. R. Brownell* (DAO); 3 miles E of Tolstoi, 10 July 1985, *P. M. Catling* s.n. (DAO); 1.5 miles E of Stuartburn, 10 July 1985, *P. M. Catling* s.n. (DAO); 0.5 mile N of Stuartburn, 13 July 1980, *N. Fox* (MMM)). All of these additional sites are in open prairie dominated by *Andropogon gerardii*. This plant was previously reported only from Kleefeld (Love and Bernard 1959; mapped by White and Johnson 1980) and Winnipeg valley (Scoggan 1979: 1227).

Literature Cited

Boivin, B. 1966–1967. Énumération des plantes du Canada. Reprinted from *Le Naturaliste canadien* in *Provancheria, Mémoires de l'Herbier Louis-Marie, Faculté d'Agriculture, Université Laval* 6. 425 pp.

- Boivin, B.** 1967–1972. Flora of the prairie provinces, parts 1, 2, 3 and 4. Reprinted from *Phytologia* in *Provancheria, Mémoires de l'Herbier Louis-Marie, Faculté d'Agriculture, Université Laval* 2, 202 pp.; 3, 185 pp.; 4, 224 pp.; and 5, 189 pp.
- Boivin, B.** 1981. Flora of the prairie provinces, part V. *Provancheria, Mémoires de l'Herbier Louis-Marie, Faculté d'Agriculture, Université Laval*, 12. 108 pp.
- Cody, W. J.** 1980. *Wolffia columbiana* (Lemnaceae) watermeal, new to Manitoba. *Canadian Field-Naturalist* 94(2): 193–194.
- Cody, W. J., and W. Krivda.** 1974. *Carex maritima* Gunn., an adventive sedge at The Pas, Manitoba. *Blue Jay* 32: 25–26.
- Cody, W. J., and J. D. Lafontaine.** 1975. The fern genus *Woodsia* in Manitoba. *Canadian Field-Naturalist* 89: 66–69.
- Johnson, K. L.** 1985. Another new orchid: the Prairie White Fringed Orchid (*Platanthera leucophaea*). *Manitoba Naturalists Society Bulletin* 8(2): 12.
- Looman, J.** 1969. Distribution extensions of Manitoba plant species. *Canadian Field-Naturalist* 83: 392.
- Looman, J.** 1973. Some new and interesting plant records for the prairie provinces. *Blue Jay* 31: 176–179.
- Looman, J., and K. F. Best.** 1979. Budd's flora of the Canadian prairie provinces. Agriculture Canada, Research Branch, Publication 1662. 863 pp.
- Love, D., and J. P. Bernard.** 1959. Flora and vegetation of the Otterburne area, Manitoba, Canada. *Svensk Botanisk Tidskrift* 53(4): 335–461.
- Riley, J. L., and S. Walshe.** 1985. New and interesting vascular plant records for northern Ontario. *Canadian Field-Naturalist* 99: 30–33.
- Rydberg, P. A.** 1932. Flora of the prairies and plains of central North America. New York Botanical Garden, New York. 969 pp.
- Ritchie, J. C.** 1956. Additions and extensions to the flora of Manitoba. *Rhodora* 58(695): 321–325.
- Scoggan, H. J.** 1957. Flora of Manitoba. National Museum of Canada, Bulletin No. 140, Biological Series Number 47. 619 pp.
- Scoggan, H. J.** 1978–1979. The flora of Canada. Parts 1–4. National Museum of Natural Sciences, Publications in Botany 7(1): 1–89, 7(2): 93–545, 7(3): 547–1115, 7(4): 1117–1711.
- Sheviak, C. J., and M. L. Bowles.** 1986. The prairie fringed orchids: a pollinator-isolated pair. *Rhodora* 88: 267–290.
- White, D. J., and K. L. Johnson.** 1980. The rare vascular plants of Manitoba. Ottawa, Syllogeus (National Museum of Natural Sciences) 27. 52 pp. + maps.
- Wiegand, K. M.** 1900. *Juncus tenuis* Willd. and some of its North American allies. *Torrey Botanical Club Bulletin* 27(10): 511–527.

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Clutch Size of the Blanding's Turtle, *Emydoidea blandingi*, in Massachusetts

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DePari, Joseph A., Madeleine H. Linck, and Terry E. Graham. 1987. Clutch Size of the Blanding's Turtle, *Emydoidea blandingi*, in Massachusetts. *Canadian Field-Naturalist* 101(3): 440-442.

Clutch size of large Blanding's Turtles, *Emydoidea blandingi*, in eastern Massachusetts ranges from 9 to 17 (mean $13.0 \pm \text{SD } 1.8$, $n = 21$). There is no significant correlation between clutch size and female size for 17 females with plastron lengths ≥ 200 mm.

Key Words: *Emydoidea blandingi*, Blanding's Turtle, Clutch size, reproduction, Massachusetts.

Significant contributions to our knowledge of the ecology of the Blanding's Turtle, *Emydoidea blandingi*, have been made recently by Gibbons (1968), Graham and Doyle (1977, 1979), Congdon et al. (1983), and Baker and Gillingham (1983). This paper provides additional data on clutch size of the Blanding's Turtle from Massachusetts.

Clutch size data for the Blanding's Turtle were obtained during a field study conducted from April 1980 to June 1984 at the Great Meadows National Wildlife Refuge in Concord, Middlesex County, Massachusetts ($42^\circ 28'30''\text{N}$; $71^\circ 20'\text{W}$). A description of the study area, located 24 km northwest of Boston and 3.2 km north of Concord center, is provided by Graham and Doyle (1977).

Clutch size was determined by X-ray photography (mean $12.1 \pm \text{SD } 2.4$, $n = 6$ clutches) using a modification of the method of Gibbons and Greene (1979) and by excavation of natural nests and nests constructed in captivity by wild-caught females (mean $13.2 \pm \text{SD } 1.1$, $n = 14$ clutches from 12 females). Female turtles were X-rayed at 70mA and 50kV for 0.4 seconds at a distance of approximately 0.6 meters (Figure 1). Clutch size determined by X-ray did not differ significantly from that determined by nest excavation (Mann-Whitney test, two-tailed, $P > 0.20$).

Clutch sizes ranged from 9 to 16 (mean $12.9 \pm \text{SD } 1.6$, $n = 20$), and were distributed as follows: 9 eggs (1 clutch), 10 eggs (1 clutch), 11 eggs (1 clutch), 12 eggs (3 clutches), 13 eggs (8 clutches), 14 eggs (4 clutches), 16 eggs (2 clutches). There was no significant correlation between clutch size and female size for turtles ranging from 200 to 220 mm (mean $211.3 \pm \text{SD } 5.9$ mm, $n = 17$) in greatest plastron length (Figure 2). Data from females with plastron

lengths of less than 200 mm are necessary to resolve the actual relationship between clutch size and female size for our population. The smallest adult female reported from this population had a plastron length of 181.4 mm (Graham and Doyle 1979). The wide range of clutch sizes produced by turtles differing by no

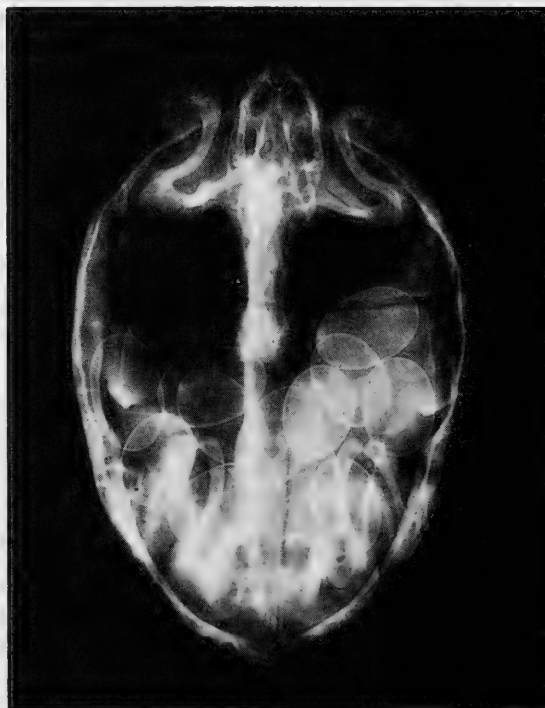


FIGURE 1. X-ray photograph of a Blanding's Turtle (211 mm plastron length) containing 13 shelled oviducal eggs.

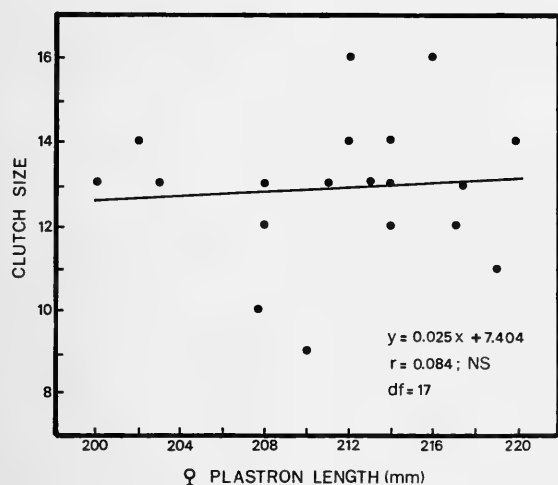


FIGURE 2. Relationship between clutch size and plastron length for 17 Blanding's Turtles from Great Meadows National Wildlife Refuge in Massachusetts. One female (212 mm plastron length) produced 16 eggs in 1982 and 14 eggs in 1983, another (214 mm plastron length) produced 14 eggs in 1982 and 13 eggs in 1984, resulting in a total of 19 clutches.

more than 20 mm in plastron length suggests that a clutch size to female size correlation, if present, may be weak for this Massachusetts population of Blanding's Turtles.

Clutch size in the Blanding's Turtle appears to be highly variable (Table 1). Our results and the additional report of 17 by Graham and Doyle (1979) indicate that the clutch size of large Blanding's Turtles from our Massachusetts population ranges from 9 to 17 (mean $13.0 \pm SD 1.8$, $n = 21$). We suggest that the range of 6-11 often quoted in general species accounts (Pope 1949; Carr 1952; Ernst and Barbour 1972; Moll 1979; Pritchard 1979) is too conservative and does not represent the full range of clutch sizes found in this species. It may be more representative of the range encountered in populations from the midwestern United States and Canada. The data suggest that some midwestern turtles mature at a smaller size, produce fewer eggs, and attain a smaller maximum size (Congdon et al., 1983; Gibbons 1968). However, the reports of Breckenridge (1970), Brewster (1982), and the observation of P. Petokas (personal communication) indicate that large females and large clutch sizes are not unique to our population.

TABLE 1. Clutch size reports for the Blanding's Turtle, *Emydoidea blandingi*. CL = carapace length, PL = plastron length.

Clutch size			Female size (mm)			Location	Source
Size	Mean	n	Size	Mean	n		
3-15	10.0	90	160-210	184.5 PL	~100	Livingston County, SE Michigan	Congdon et al. 1983
6		1	134.6 CL		1	Long Point, Ontario	Adams and Clark 1958
6-10	—	—	240 CL (maximum)		—	Illinois	Cahn 1937
—	8.3	8	190 PL (maximum)		67	SW Michigan	Gibbons 1968
11		1	217 CL		1	Nova Scotia	Bleakney 1963
11		1	not reported		1	Port Maitland, Ontario	Brown 1927
11		1	not reported		1	Point Pelee, Ontario	Snyder 1921
7-11	8.8	5	173 PL (11 eggs) 179 PL (9 eggs) 195 CL (8 eggs)		1	Long Point, Ontario	W. Weller (personal communication)
9-16	12.9	20	200-220	211.3 PL	17	Concord, Middlesex County, Massachusetts	this study
17		1	202.4 PL		1	Concord, Middlesex County, Massachusetts	Graham and Doyle 1979
17		1	260.3 CL		1	Minnesota	Breckenridge 1970
19		1	229 PL		1	Trempeleau County, Wisconsin	Brewster 1982
20		1	228 PL		1	Clayton, Jefferson County, New York	P. Petokas (personal communication)

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Literature Cited

- Adams, M. S., and H. F. Clark. 1958. A herpetofaunal survey of Long Point, Ontario, Canada. *Herpetologica* 14(1): 8-10.
- Baker, R. E., and J. C. Gillingham. 1983. An analysis of courtship behavior in Blanding's turtle, *Emydoidea blandingi*. *Herpetologica* 39(2): 166-173.
- Bleakney, J. S. 1963. Notes on the distribution and life histories of turtles in Nova Scotia. *Canadian Field-Naturalist* 77(2): 67-76.
- Breckenridge, W. J. 1970. Reptiles and Amphibians of Minnesota. University of Minnesota Press, Minneapolis, Minnesota.
- Brewster, K. N. 1982. Life history notes: *Emydoidea blandingi* (Blanding's turtle). *Herpetological Review* 13(2): 48.
- Brown, J. R. 1927. A Blanding's Turtle lays its eggs. *Canadian Field-Naturalist* 41(8): 185.
- Cahn, A. R. 1937. The turtles of Illinois. Illinois Biological Monographs 16(1-2): 1-218.
- Carr, A. 1952. Handbook of Turtles. Cornell University Press, Ithaca, New York.
- Congdon, J. D., D. W. Tinkle, G. L. Breitenbach, and R. C. van Loben Sels. 1983. Nesting ecology and hatching success in the turtle *Emydoidea blandingi*. *Herpetologica* 39(4): 417-429.
- Ernst, C. H., and R. W. Barbour. 1972. Turtles of the United States. The University Press of Kentucky, Lexington, Kentucky.
- Gibbons, J. W. 1968. Observations on the ecology and population dynamics of the Blanding's turtle, *Emydoidea blandingi*. *Canadian Journal of Zoology* 46: 288-290.
- Gibbons, J. W., and J. L. Greene. 1979. X-ray photography: a technique to determine reproductive patterns of freshwater turtles. *Herpetologica* 35(1): 86-89.
- Graham, T. E., and T. S. Doyle. 1977. Growth and population characteristics of Blanding's turtle, *Emydoidea blandingii*, in Massachusetts. *Herpetologica* 33: 410-414.
- Graham, T. E., and T. S. Doyle. 1979. Dimorphism, courtship, eggs, and hatchlings of the Blanding's turtle, *Emydoidea blandingii* (Reptilia, Testudines, Emydidae) in Massachusetts. *Journal of Herpetology* 13(1): 125-127.
- Moll, E. O. 1979. Reproductive cycles and adaptations. Pp. 305-332 in *Turtles: perspectives and research*. Edited by M. Harless and H. Morlock. John Wiley and Sons, New York, New York.
- Pope, C. H. 1949. Turtles of the United States and Canada. Alfred A. Knopf, Inc., New York.
- Pritchard, P. C. H. 1979. Encyclopedia of turtles. T.F.H. Publications, Inc., Neptune, New Jersey.
- Snyder, L. L. 1921. Some observations on Blanding's Turtle. *Canadian Field-Naturalist* 35(1): 17-18.

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Marsh Saxifrage, *Saxifraga hirculus*, and *Diapensia*, *Diapensia lapponica*, in northern British Columbia

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Clement, Christopher J. E. 1987. Marsh Saxifrage, *Saxifraga hirculus*, and *Diapensia*, *Diapensia lapponica*, in northern British Columbia. *Canadian Field-Naturalist* 101(3): 443-445.

Two species are reported as additions to the flora of British Columbia: *Saxifraga hirculus* (Marsh Saxifrage) and *Diapensia lapponica* (*Diapensia*). *Diapensia lapponica* represents a new family [DIAPENSIACEAE] for British Columbia. Some phytosociological relationships of the described species are presented.

Key Words: *Saxifraga hirculus*, Marsh Saxifrage, *Diapensia lapponica*, *Diapensia*, alpine, British Columbia, new records, phytosociology.

During July and August of 1980 a reconnaissance vegetation-soils study was conducted in northern British Columbia by the Terrestrial Studies Branch of the B.C. Ministry of Environment as part of an ongoing project examining wolf-caribou relationships within two disjunct areas (Level Mountain and the Horseranch Range: see Figure 1). The remote and isolated nature of the study areas yielded an opportunity to collect plants in a part of British Columbia where limited botanical work has been undertaken. Previous studies in the general vicinity have resulted in valuable floristic records for British Columbia (Pojar et al. 1977; Douglas and Ruyle-Douglas 1978). This paper reports two species new for the British Columbia flora: *Saxifraga hirculus* L., Marsh Saxifrage, and *Diapensia lapponica* L., *Diapensia*. The latter also represents a new family for the British Columbia flora.

Voucher specimens were deposited in the Herbarium of the British Columbia Provincial Museum, Victoria; duplicates of *Saxifraga hirculus* were also deposited at the Herbarium of the University of British Columbia, Vancouver.

Data collected at the plant sighting locations are available on request from J. W. van Barneveld, Waste Management Branch, Ministry of Environment, Parliament Buildings, Victoria. In addition, maps of vegetation landscapes [C. J. Clement. 1981. *Forest zonation and vegetation landscapes for the Horseranch Range* and *Forest zonation and vegetation landscapes for the Level Mountain Range*, British Columbia Ministry of Environment, Victoria] and terrain units [M. Fenger. 1981. *Forest zonation, vegetation landscapes and general terrain description for the Horseranch Range*, and *Forest zonation, vegetation landscapes and general terrain description for the Level Mountain Range*, British Columbia

Ministry of Environment, Victoria] for the study areas are available.

Species Accounts

Saxifraga hirculus, MARSH SAXIFRAGE

Saxifraga hirculus (C. Clement, LM8015, 31 July 1980) was found in a minerotrophic fen at an elevation of 910 m near Level Mountain. The site was level with a subhydric moisture regime and the poorly drained organic layer had a Typic Fibrisol soil development (soils are named according to the Canadian System of Soil Classification: Canada Soil Survey Committee 1978). The specimens were growing in a matrix of *Carex stichensis* with scattered *Betula glandulosa*, and *Salix* spp.

Saxifraga hirculus is typically found in cold wetlands associated with tundra environments and heathlands (Welsh 1974; Looman and Best 1979; Porsild and Cody 1980). It has been collected throughout Alaska, specifically in the southern portion adjacent to British Columbia (Hultén 1968; Welsh 1974). It is interesting to note that *Saxifraga hirculus* was reported from British Columbia by Henry (1915). Boivin (1967) disputed this report as it was not substantiated by any collections. Later, *Saxifraga hirculus* was collected by S. and S. Shchanen (Ketchum Lake, 71/247, 18 August 1971) and by T. C. Brayshaw and D. F. Polster (Liard Plateau, 26 July 1974), but neither occurrence was reported.

Diapensia lapponica, DIAPENSIA

During the course of the survey of the Horseranch Range, *Diapensia lapponica* (C. Clement, HR8039, 21 August 1980) was recorded at five different sample locations representing two general types of site. *Diapensia lapponica* was noted on four occasions with low cover values (< 1 to 2% cover) growing on middle alpine slopes under the influence of

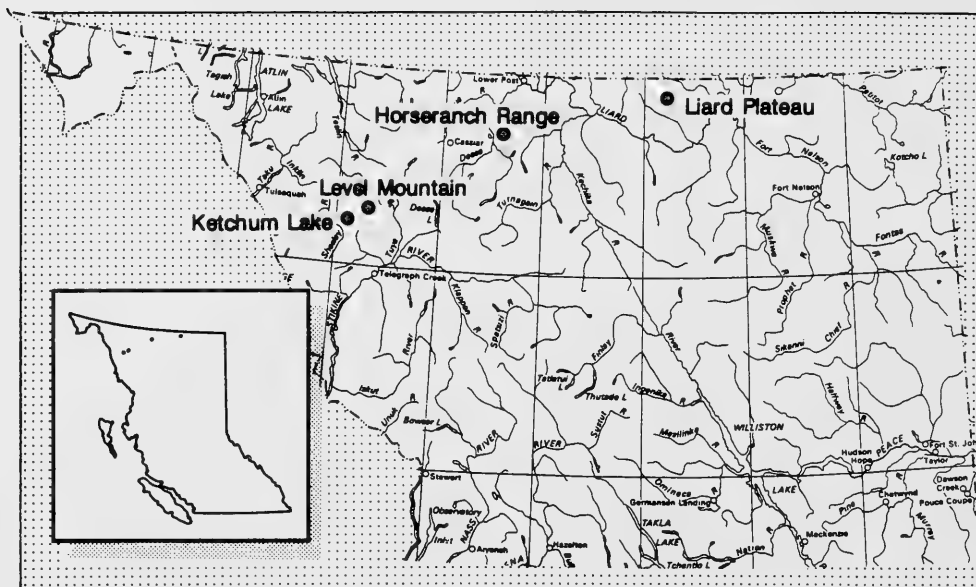


FIGURE 1. Location of collection sites in British Columbia (see text for details).

solifluction and seepage. Elevations and slopes ranged from 1505 m to 1900 m and from 9 to 30 percent, respectively. These sites were north and east facing with mesic to subhygric soil moisture conditions; parent materials were colluvial and morainal. Soils were predominantly Orthic Regosols with one site being an Orthic Dystric Brunisol. On these sites *Carex microchaeta* occurred constantly sometimes with high cover (50%). Other species which occurred frequently included *Dryas integrifolia*, *Salix polaris*, *Poa arctica*, *Festuca altaica*, *Cassiope tetragona*, *Salix glauca*, *Betula glandulosa*, *Hierochloa alpina* and *Polytrichum norvegicum*.

Diapensia lapponica was recorded with the highest cover value (10%) on an exposed wind-swept gravelly ridge at an elevation of 1640 m. The soil was a well drained Orthic Regosol in a stony morainal material. Exposed stones (unvegetated) made up 40% of the site and the soil had a xeric moisture regime. Dominant plants were *Loiseleuria procumbens*, *Vaccinium vitis-idaea*, *Dryas integrifolia*, *Alectoria ochroleuca* and *Salix polaris*.

Diapensia lapponica occurs in alpine and arctic tundra on acidic rocks and gravels from Alaska east to Labrador (Hultén 1968; Welch 1974; Porsild and Cody 1980).

Discussion

Saxifraga hirculus is a circumpolar species described from Lapland, Siberia and Switzerland. Hultén (1968) indicates collections throughout Alaska and the Yukon. Considering the British Columbia collections are from disparate far north locations and that no sightings were made in the Spatsizi area by either Pojar or myself, it is likely that the Level Mountain and Ketchum Lake collections represent southern limits of occurrence for *Saxifraga hirculus*.

Diapensia lapponica, described from Lapland and Sakhalin (subsp. *obovata*), appears to be confined in distribution to Alaska, the western Yukon and eastern Siberia (Hultén 1968); no records are reported for the eastern Yukon or the Northwest Territories. One collection was made in the St. Elias Mountains of Alaska south of the 60th parallel. Interestingly, the Horseranch Range is an isolated monolith, about 40 km south of the Yukon. No sightings were recorded on Level Mountain. It is possible, given the limited amount of botanical work done in extreme northern British Columbia, that other populations of *Diapensia lapponica* exist in the northern Cassiar Mountains. The Horseranch Range locations may represent southern and eastern limits of occurrence for the species.

Acknowledgments

Thanks are extended to A. Ceska for verifying specimens of *Saxifraga hirculus* and *Diapensia lapponica*, to R. L. Taylor for verifying *Saxifraga hirculus*, to L. Pavlick for verifying Poaceae specimens, to R. Page for identifying lichens and to M. Fenger for assistance with field work. I would also like to thank A. Ceska and J. van Barneveld for their assistance in providing reference material, advice and suggestions.

Literature Cited

- Boivin, B. 1967. Énumération des plantes du Canada. Le Naturaliste canadien 94: 625–655.
- Canada Soil Survey Committee, Subcommittee on Soil Classification. 1978. The Canadian system of soil classification. Canada Department of Agriculture Publication 1646. Supply and Services Canada, Ottawa. 164 pp.
- Douglas, G. W., and G. Ruyle-Douglas. 1978. Contributions to the floras of British Columbia and the Yukon Territory — I. Vascular Plants. Canadian Journal of Botany 56: 2296–2302.

- Henry, J. K. 1915. Flora of southern British Columbia and Vancouver Island with many references to Alaska and northern species. W. J. Gage and Co. Ltd., Toronto.
- Hultén, E. 1968. Flora of Alaska and neighboring territories. Stanford University Press, Stanford.
- Looman, J., and K. F. Best. 1979. Budd's flora of the Canadian prairie provinces. Research Branch, Agriculture Canada, Ottawa, Publication 1662. 863 pp.
- Pojar, J., K. J. Beamish, V. J. Krajina, and L. K. Wade. 1977. New records and range extensions of vascular plants in northern British Columbia. Syesis 9 [1976]: 45–57.
- Porsild, A. E., and W. J. Cody. 1980. Vascular plants of continental Northwest Territories, Canada. National Museum of Natural Sciences, National Museums of Canada, Ottawa.
- Welsh, S. L. 1974. Anderson's flora of Alaska and adjacent parts of Canada. Brigham Young University Press, Provo Utah.

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Fledgling Gray Jay, *Perisoreus canadensis*, Survives Severe Snow Storm

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Walley, William J. 1987. Fledgling Gray Jay, *Perisoreus canadensis*, survives severe snow storm. Canadian Field-Naturalist 101(3): 445–446.

Three color-banded nestling Gray Jays were apparently forced to vacate their poorly protected nest during a severe late April snow storm. The sighting of one of these young in mid-June proved that at least one young survived.

Key Words: Gray Jay nestlings, *Perisoreus canadensis*, colored bands, snow storm, survival.

On 17 March 1984 a Gray Jay, *Perisoreus canadensis*, nest was found in boreal forest 3 km south of Moon Lake by Highway 10 in Riding Mountain National Park, Manitoba (50°08'N; 100°05'W). The nest was in a 3.5 m White Spruce, *Picea glauca*, less than a meter above the snow and 1.5 m above the ground — the lowest situated of 26 nests I found in the park between 1973 and 1985. The young spruce was one of a small stand by the south side of the highway clearing. Snow plowed from the highway just reached the tree trunk.

The nest was discovered when the male flew to it, presumably to feed the female who was apparently incubating. The nest was on the east side of and against the slim trunk. Although the branches

afforded some protection, the open ditch and highway left it exposed to wind from the northwest, north or northeast. The clutch size was not determined lest Coyotes, *Canis latrans*, which were feeding on a Moose, *Alces alces*, carcass some 90 m away, would follow my trail to the nest.

On 15 April single overlapping type celluloid coloured leg bands (red, blue and yellow) were placed on the left tarsus of each of 3 nestlings, judged to be 9–11 days old, by the degree the eyes had opened. In Gray Jays, the eyes open between the 10th and 12th days after hatching (Rutter 1969).

In the late afternoon of 26 April, one of the most severe spring storms known across the southern Canadian prairies hit the area. In the next two days,

32 cm of snow fell, with the temperature ranging between -6°C and -1.4°C on 27-28 April. Winds up to 83 KPH blew consistently from the northeast and north. All weather data were recorded at Dauphin airport (32 km north of the nest site and 400 m lower elevation).

On 29 April the nest was visited to determine the fate of the birds. The structure was found to be vacated and covered with soft snow to a depth of approximately 4 cm which suggested that the young, believed to be 20-22 days old on 26 April, had fledged prior to the storm. Gray Jays fledged at about 20 days of age (Rutter 1969), but this can be delayed in adverse weather as I observed at a nest in the park in 1979. When the snow was brushed away, the depressed surface of the nest was found to contain a concave 2 cm thickness of ice and hard snow with frozen droppings in and on this shell. Evidently some snow had melted from the body heat of the birds before they vacated the nest, and then had refrozen.

A dense Black Spruce, *Picea mariana*, stand some 30 meters south of the nest would have provided protection for the fledglings if they reached it. However, given the severity of the storm and the awkwardness of fledgling jays, it seemed unlikely that any of them survived. Winds did not subside until the

afternoon of 28 April, and it seemed improbable that the birds would have been able to resist the storm for 48 hours.

On 9 June 1984 when I was birding in the vicinity of the nest site, a group of Gray Jays, including three adults and two sooty juveniles, flew into nearby spruces. Both juveniles were examined with 7x binoculars at 8-12 m; one was unbanded but the other had a yellow band on the left tarsus. This confirmed that at least one of the young survived the late April storm, further evidence of the hardy nature of this early-nesting species.

Acknowledgments

Appreciation is extended to Spencer Sealy for advice concerning bands, to Doug Walker for his assistance in the field and to Parks Canada for permission to band the jays.

Literature Cited

Rutter, R. J. 1969. A contribution to the biology of the Gray Jay (*Perisoreus canadensis*). Canadian Field-Naturalist 83(4): 300-316.

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A Hadrosaurine Dinosaur from the Bearpaw Formation (Late Cretaceous: Late Campanian) of Saskatchewan

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Tokaryk, Tim T. 1987. A hadrosaurine dinosaur from the Bearpaw Formation (Late Cretaceous: Late Campanian) of Saskatchewan. Canadian Field-Naturalist 101(3): 446-448.

Not familiar to most vertebrate paleontologists is a partial skeleton of a large hadrosaurine from the Snakebite Member of the Bearpaw Formation of Saskatchewan (Late Campanian). Although the specimen has been briefly referred to by two authors, no description has followed until now. This occurrence is the first to be recorded from marine sediments north of Montana. The specimen implies that it was derived from a fauna to the northwest that was transitional between the typical Judithian and Edmontonian assemblages.

Key Words: Hadrosaurine, Bearpaw Formation, Saskatchewan.

In 1961, staff of the Saskatchewan Museum of Natural History (SMNH) recovered a partial dinosaur skeleton from the marine Bearpaw Formation near Main Centre, Saskatchewan.

Caldwell (1968: 76) reported on the Bearpaw Formation in the South Saskatchewan River Valley and this specimen. He remarked that it occurred "a little above the middle of the Snakebite clay in the type

area," and "is exceptional insofar as the hadrosaur occurs in beds least likely to preserve such remains." A brief reference to this specimen occurred much later (Tokaryk 1986).

Horner (1979) surveyed dinosaurs from marine deposits in the United States and Mexico, but aside from Caldwell's and Tokaryk's brief notations, no published description exists from areas north of the

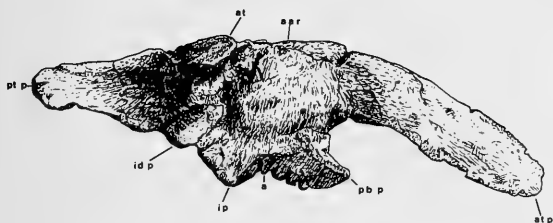


FIGURE 1. Hadrosaurinae, genus and species indeterminate, right ilium SMNH P1810.1, lateral view. Abbreviations; a: acetabulum; aar: anterior antitrochanter ridge; at: antitrochanter; atp: anterior process; idp: ischiadic peduncle; ip: ischial peduncle; pbp: pubic peduncle; ptp: posterior process. Scale bar equals 100 mm.

49th parallel. The hadrosaur from the Snakebite Member and three other Bearpaw dinosaurs from western Canada are discussed in this paper.

Systematic Paleontology

Class Reptilia

Order Ornithischia

Family Hadrosauridae

Subfamily Hadrosaurinae

Genus indeterminate

Referred specimen: Partial skeleton (right metacarpal, partial ulnae and radii, humeri, right coracoid, ungual phalanx from digit IV of right pes, left femur, ilia, sacral and caudal vertebrae, two ribs), SMNH P1810.1 (Table 1).

Description and Discussion

Brett-Surman (1975: 22) has suggested that ilia are useful elements in the diagnosis of hadrosaurs and has further suggested that it is "possible to make a generic determination using this element alone." Although Morris (1978: 204) pointed out the variation of ilia in *Hypacrosaurus*, this variation does not rule out the possibility of subfamily determination.

The right ilium of the Saskatchewan specimen (Figure 1) is well preserved and resembles ilia of two reported hadrosaurines. In lateral view, the posterior process appears to be short and moderately deflected. The ischiadic peduncle is prominent compared with other hadrosaurines (Davies 1983: 86–87). Dorsal to the ischiadic peduncle is a small antitrochanter extending towards the acetabulum. A larger antitrochanter extending towards the ischiadic peduncle would indicate a lambeosaurine-like ilium as noted by Davies (1983: 74). The pubic peduncle is sharp but does not extend far anteriorly. The anterior process is relatively tall dorsoventrally, and does not

TABLE 1. Measurements of Hadrosaurine, SMNH P1810.1.

	SMNH P1810.1
Length of left femur	1200 mm
Minimum circumference of femur	570 mm
Length of right humerus	660 mm
Length of ilium	1030 mm

taper to a sharp apex. The anterior portion of the acetabulum is slightly deflected outward.

Davies (1983) illustrated two hadrosaurine ilia that resemble the present specimen: *Prosaurolophus* (typically of the Judithian age) and *Edmontosaurus* (occurring in the Horseshoe Canyon Formation and Lance Equivalents). The ischiadic peduncle of P1810.1 is sharp as in *Prosaurolophus* but the short anterior antitrochanter ridge and thick anterior process are also comparable to *Edmontosaurus*. Thus this specimen cannot be referred to either genus, although strong similarities to both are noted, suggesting an intermediate form.

Caldwell (1968: 76) concluded that the Saskatchewan specimen was late Campanian (*Baculites reesidei-jenseni* zones). This portion of the Bearpaw Formation represents a time between the Upper Judith River and Horseshoe Canyon formations of the southern plains of Alberta (Caldwell 1968: 3, text and Figure 1). The Bearpaw hadrosaurine is stratigraphically intermediate between known Judithian and Edmontonian dinosaur faunas and represents a terrestrial faunal stage hitherto unsampled in western Canada.

The nearest contemporaneous shoreline from which the specimen might have originated lay as much as 500 km to the northwest in the Edmonton area (Williams and Burk 1970: Figures 12–21). There is no indication of paleocurrent because of the large distance to the nearest shoreline. Continental deposits there are overlain by younger beds and are not exposed.

Other dinosaurs are now known from the Bearpaw Formation of western Canada. The Tyrrell Museum of Palaeontology (TMP) has an unprepared, semi-articulated skeleton of a juvenile hadrosaur (TMP 83.64.3) recovered near Manyberries, Alberta, and the proximal end of an ornithomimid metatarsal (TMP 78.28.12), also found near Manyberries (Philip Currie, personal communication). Wann Langston, Jr., then of the National Museum of Natural Sciences, collected fragments of a ceratopsian (NMC 40500) from Bearpaw sediments near the South Saskatchewan River in Saskatchewan (1959, unpublished field notes), all of which have yet to be studied in detail.

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Literature Cited

- Brett-Surman, M. K.** 1975. The appendicular anatomy of hadrosaurian dinosaurs. M. A. thesis, University of California, Berkeley. 70 pp.
- Caldwell, W. G. E.** 1968. The Late Cretaceous Bearpaw Formation in the South Saskatchewan River Valley. Saskatchewan Research Council, Geology Division, Report Number 8. 86 pp.
- Davies, K. L.** 1983. Hadrosaurian dinosaurs of Big Bend National Park, Brewster County, Texas. M. A. thesis, University of Texas at Austin. 235 pp.
- Horner, J. R.** 1979. Upper Cretaceous dinosaurs from the Bearpaw Shale (marine) of south-central Montana with a checklist of Upper Cretaceous dinosaur remains from marine sediments in North America. *Journal of Paleontology* 53: 566-577.
- Morris, W. J.** 1978. *Hypacrosaurus altispinus?* Brown from the Two Medicine Formation, Montana, a taxonomically indeterminate specimen. *Journal of Paleontology* 52: 200-205.
- Tokaryk, T. T.** 1986. Ceratopsian dinosaurs from the Frenchman Formation (Upper Cretaceous) of Saskatchewan. *Canadian Field-Naturalist* 100: 192-196.
- Williams, G., and C.F. Burk, Jr.** 1970. Upper Cretaceous. Pages 169-189 in *Geological history of western Canada*. Edited by R. G. McCrossan and R. P. Glaister. Alberta Society of Petroleum Geologists, Calgary.

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Short-eared Owl, *Asio flammeus*, Predation on Leach's Storm-Petrels, *Oceanodroma leucorhoa*, in Massachusetts

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Holt, Denver W. 1987. Short-eared Owl, *Asio flammeus*, predation on Leach's Storm-Petrels, *Oceanodroma leucorhoa*, in Massachusetts. *Canadian Field-Naturalist* 101(3): 448-450.

Twenty-two Leach's Storm-Petrels and two Wilson's Storm-Petrels were recorded as prey of the Short-eared Owl. The only known Leach's Storm-Petrel colony south of Maine is 80 km away, with a breeding population of less than 10 pairs. Leach's Storm-Petrels are believed to come to land only at night and only during the breeding season. Short-eared Owls are known to capture petrels as they enter and exit nesting burrows. I suggest Short-eared Owls are capturing prospecting or breeding Leach's Storm-Petrels and this may represent a new petrel colony site.

Key Words: Storm-Petrels, *Oceanodroma leucorhoa*, Short-eared Owls, *Asio flammeus*, predation, nesting, Massachusetts.

Owl predation on coastal nesting seabirds is well documented (Bent 1938; Austin 1948; Vermeer 1970; Southern et al. 1982; Nisbet and Welton 1984). However, owl predation on pelagic seabirds is less well documented (Schweppenbourg 1907; Alexander 1935; Saunders 1962; Abs et al. 1965; Harris 1969; Woods 1970; Glue 1977; French 1979; Charles Huntington and Jon Lien, personal communication) and is probably overlooked where it occurs. In this note, I report the occurrence of Short-eared Owl, *Asio flammeus*, predation on Storm-Petrels in Massachusetts, and discuss possible origins of the petrels and capture methods used by the owls.

Monomoy National Wild Refuge (41°38'N,

69°58'W) is a barrier beach island that extends approximately 14 km south into the Atlantic Ocean from the "elbow" of Cape Cod, Chatham, Massachusetts. The refuge was cut by a 1978 winter storm and consequently exists as two islands, north and south. Most petrel remains were found on the southeastern third of the south island, near Powder Hole. I collected pellets cast by the owls and the remains of prey eaten by the owls as part of an ongoing food study.

Between 1982 and 1984, 22 Leach's Storm-Petrels, *Oceanodroma leucorhoa*, and two Wilson's Storm-Petrel, *Oceanites oceanicus*, were recorded as prey of the Short-eared Owl. No petrel remains were recorded

in 1985 and 1986 when coverage was more limited. Although some storm-petrel skulls were found in owl pellets, preyed-upon storm-petrel carcasses were better indicators of total numbers because the owls did not always consume the heads of petrels.

Short-eared Owls ate at least two Leach's Storm-Petrels in 1982, eight Leach's Storm-Petrels and one Wilson's Storm-Petrel in 1983, and twelve Leach's Storm-Petrels and one Wilson's Storm-Petrel in 1984. Remains of petrels were first noted at approximately the beginning of July and continued through August.

Carcasses were found eaten in a manner similar to the one described by Brewster (1879) and Bent (1938) for Short-eared Owls, by Nisbet (1975) for Great Horned Owls, *Bubo virginianus*, and by Holt and Lortie (1983) for Short-eared Owl predation on Common Terns, *Sterna hirundo*. Most carcasses were found on their backs, with the breast meat eaten away, exposing the sternum and keel. Pieces of the keel were often bitten out during feeding. The wings were often severed from the body or the skin peeled back along the humerus, radius and ulna. The neck was either broken, or the cervical vertebrae were severed and the head lay near the carcass. The legs were dismembered or swallowed.

Several petrel species have been recorded in the diet of the Short-eared Owl. Abs et al. (1965) reported that the Galapagos Short-eared Owl, *A. galapagoensis*, on islands devoid of mammalian prey, fed mainly on birds, especially the Wedge-rumped Storm-Petrel, *Oceanodroma tethys*, and Band-rumped Storm-Petrel, *Oceanodroma castro*. Harris (1969) reported that Galapagos Short-eared Owls prey more heavily on *O. castro* because of the owls' nocturnal habits. Harris (1969) also observed that the owls prey on *O. tethys* by waiting at burrow crevices and leaping feet-first at the petrels as they departed. On one occasion he observed an owl reaching into a burrow feet-first while leaning back on its wings. Woods (1970) reported that on the Falkland Islands Gray backed Storm-Petrels, *Garradina nereis*, and Falkland Diving-Petrels, *Pelecanoides urinatrix*, were taken by Short-eared Owls as they entered and exited their nest burrows. Glue (1977) reported the British Storm-Petrel, *Hydrobates pelagicus*, in the diet of the Short-eared Owl on Skomer Island off the Welsh coast, but felt the petrels were of little importance as a food source. Other instances of owl predation on petrels include Barn Owl, *Tyto alba* (Bonnot 1928), Little Owl, *Athene noctua* (Alexander 1935), Great Horned Owl (French 1979) and an immature Saw-whet Owl, *Aegolius acadicus*, on Kent Island, New Brunswick (C. Huntington, personal communication).

There are two questions concerning the predation on Monomoy: 1) are Leach's Storm-Petrels breeding

there? 2) how are the resident Short-eared Owls capturing the petrels?

The habitat is dominated by sand dunes and a beach grass (*Ammophila breviligulata*)/beach heath (*Hudsonia tomentosa*) community, with scattered fresh water ponds bordered by Bayberry (*Myrica pennsylvanica*), Poison Ivy (*Rhus radicans*), Salt-spray Rose (*Rosa rugosa*) and Narrow-leaved Cattail (*Typha angustifolia*). This is unlikely Leach's Storm-Petrel nesting habitat (C. Huntington, personal communication).

Searches were conducted along sand dune areas where erosion had undercut shrubs exposing small sandy cliffs and a potential root and tunnel burrow system. The sand appears too loose to allow nesting burrows to be dug. However, an old cement building foundation near the areas of petrel predation appears to be a possible nesting area, since Leach's Storm-Petrels on Penikese Island, Buzzards Bay, Massachusetts, nest within the crevices of old hand-stacked rock walls. The area around this foundation was searched for burrows, and all nooks and crannies were sniffed for the distinct petrel odor on each day visit. Because of logistics of the area, less than five overnight visits per season were conducted in search of petrels. Warm, still nights in July and August were chosen because nesting petrels might easily be heard or possibly even seen. However, no evidence of petrels was found.

The population of Leach's Storm-Petrels on Penikese Island declined from 90 burrows in 1941 (Hagar in Drury 1973) to between two and six burrows in the early 1970s (Drury 1973), and is still presently less than ten active burrows in 1986 (Jeremy Hatch, personal communication). This is the only known Leach's Storm-Petrel nesting colony south of Maine. Leach's Storm-Petrels are rarely observed from shore during the summer months in Massachusetts, whereas Wilson's Storm-Petrels are occasionally seen near shore, and on foggy days may follow fishing boats into the bays around Monomoy. Leach's Storm-Petrels are observed foraging offshore at Georges Bank or the deep water upwellings along the outer limits of the Continental Shelf in southeastern Massachusetts. These areas lie approximately 175 to 200 km southeast of Monomoy. The population breeding at Penikese Island is approximately 80 km west-southwest of Monomoy.

I have observed Short-eared Owl foraging activity from 1982 to 1985 on Monomoy and Nantucket Islands, Massachusetts. I have never observed these owls to forage at sea, although I have observed them fly over bays from one land mass to another. However, these owls have populated many oceanic islands (i.e. Hawaiian, Galapagos, and Caroline: Mikkola 1983) and have been recorded boarding ships

80, 800, and 1088 km from land during October migration (Henshaw 1901; Bryan 1903; Gray 1945). This suggests that at least some of these owls are capable of long oceanic flights and/or hitchhiking on ships. Both owls which boarded the ships 800 and 1088 km from land died, while the two which boarded the ship at 80 km left as the ship approached sight of land. These accounts indicate to me that the owls were fatigued and emaciated, easily handled, and unlikely to be successful foraging at sea.

Secondly, Leach's Storm-Petrel pairs share incubation duties for approximately 1 to 5 days; $x = 3$ (Wilbur 1969). Using these incubation stints and homing experiments by Billings (1968), Wilbur (1969) calculated that a foraging mate could travel 960 km in three days, and have a foraging range of 480 km. Given this, it seems possible that petrels nesting in Massachusetts or Maine could forage in the waters off southeastern Massachusetts, possibly passing over or along Monomoy and there being captured by Short-Eared Owls. Leach's Storm-Petrels have been shown to fly over short overland routes (Billings 1968). But why wouldn't the more abundant and sometimes coastal Wilson's Storm-Petrels have shown up in more of the owl food habits?

Thirdly, Leach's Storm-Petrels are believed to come to land only during the breeding season and only at night (Cramp et al. 1977). This would argue for two points: 1) that these petrels are prospecting young adults, checking out potential colony sites (Wilbur 1969); or 2) that a breeding population of Leach's Storm-Petrels exists on Monomoy and has been overlooked.

Finally, I have identified 3806 prey items of Short-eared Owl from the islands of coastal southeastern Massachusetts and have not found any other petrel remains. Therefore, I suggest that Leach's Storm-Petrels are either inspecting Monomoy for potential nesting sites or are actively nesting there and have been overlooked. I further suggest that the Short-eared Owls are not foraging at sea, but are capturing petrels on the ground as they enter and exit burrows or possibly in flight just above the ground as the petrels perform their courtship fights.

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Literature Cited

- Abs, M., E. Curio, P. Kramer, and J. Niethammer. 1965. Zur Ernährungsweise der Eulen auf Galapagos. *Journal of Ornithologie* 106: 49-57.
- Alexander, W. B. 1935. Exhibition of, and remarks on the larder of a Little Owl (*Carine noctua*) from Skokholm Island, Pembrokeshire. *Bulletin of the British Ornithological Club* 55: 60.
- Austin, O. L. 1940. Some aspects of individual distribution in the Cape Cod tern colonies. *Bird-Banding* 11: 155-169.
- Bent, A. C. 1938. Life histories of North American birds of prey. Part 2. United States National Museum Bulletin 170: 482 pp.
- Billings, S. M. 1968. Homing in Leach's Petrel. *Auk* 85: 36-43.
- Bonnot, P. 1928. An outlaw Barn Owl. *Condor* 30: 320.
- Brewster, W. 1879. The terns of the New England coast. *Bulletin of the Nuttall Ornithological Club* 4: 13-22.
- Bryan, W. A. 1903. The Short-eared Owl (*Asio accipitrinus*) taken far out at sea. *Auk* 20: 212-213.
- Cramp, S., et al. 1977. Handbook of the birds of Europe, the Middle East and North Africa: The birds of the Western Palearctic. Volume 1. Oxford, Oxford University Press.
- Drury, W. H. 1973. Population changes in New England seabirds. *Bird-Banding* 44: 267-313.
- French, T. W. 1979. Great Horned Owl predation on Leach's Storm-Petrels in Maine. *Auk* 97: 202.
- Glue, D. E. 1977. Feeding of the Short-eared Owl in Britain and Ireland. *Bird Study* 23: 70-78.
- Gray, J. A. 1945. Land birds at sea. *Condor* 47: 215-216.
- Harris, M. P. 1969. The biology of Storm-Petrels in the Galapagos Islands. *Proceedings of the California Academy of Sciences* 37: 95-166.
- Henshaw, H. W. 1901. Birds of prey as ocean waifs. *Auk* 18: 162-165.
- Holt, D. W., and J. P. Lortie. 1983. Characteristics of Short-eared Owl predation on Monomoy National Wildlife Refuge. Massachusetts Audubon Society Report, 4 pp.
- Mikkola, H. 1983. Owls of Europe. Buteo Books, Vermillion, South Dakota.
- Nisbet, I. C. T. 1975. Selective effects of predation in a tern colony. *Condor* 77: 221-226.
- Nisbet, I. C. T., and M. J. Welton. 1984. Seasonal variations in breeding success of Common Terns: Consequences of predation. *Condor* 86: 53-60.
- Saunders, D. R. 1962. Owls feeding on young seabirds. *British Birds* 55: 591.
- Schweppenbourg, G. von. 1907. Zur Nahrung sudpalaearktischer Schleireulen. *Ornithologisches Jahrbuch Hallein* 18: 39-43.
- Southern, L. K., S. R. Patton, and W. E. Southern. 1-1982. Nocturnal predation on Larus gulls. *Colonial Waterbirds* 5: 169-172.
- Vermeer, K. 1970. Breeding biology of California and Ring-billed Gulls: a study of ecological adaptation to the island habitat. Canadian Wildlife Service Report, Number 12.
- Wilbur, H. M. 1969. Breeding biology of Leach's Storm-Petrels (*Oceanodroma leucorhoa*). *Auk* 86: 433-442.
- Woods, R. W. 1970. The avian ecology of a tussock island in the Falkland Islands. *Ibis* 112: 15-24.

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Collared Lemming, *Dicrostonyx groenlandicus*, and Bird Remains in a Lake Trout, *Salvelinus namaycush* at Maguse River, Keewatin, Northwest Territories

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Mallory, Frank F., and Michael N. Hall. 1987. Collared Lemming, *Dicrostonyx groenlandicus*, and bird remains in a Lake Trout, *Salvelinus namaycush* at Maguse River, Keewatin, Northwest Territories. *Canadian Field-Naturalist* 101(3): 451.

A Lake Trout (*Salvelinus namaycush*) caught by Inuit fishermen at Maguse River, Northwest Territories, on 19 May 1985 contained a partially digested adult Collared Lemming (*Dicrostonyx groenlandicus*) and the leg of a medium-sized bird.

Key Words: Lake Trout, *Salvelinus namaycush*, Collared Lemming, *Dicrostonyx groenlandicus*, bird, predation.

On 19 May, 1985, while fishing with a party of Inuit along the Maguse River, Keewatin, Northwest Territories, approximately 1.5 km below Maguse Lake, we caught a Lake Trout (*Salvelinus namaycush*) whose stomach contained an adult Collared Lemming (*Dicrostonyx groenlandicus*) and the tibiotarsus and tarsometatarsus (Weichert 1951) of a moderately-sized bird, possibly a duck. The ground was still covered with snow (approximately 25 cm) except on the tops of the higher ridges, and the lakes and rivers were frozen (approximately 2 m of ice on Maguse Lake), except in small sections where the water was shallow and the currents strong. The fish, caught in one of these shallow openings (1 to 2 m of water) was in good condition, and estimated to be 60 to 65 cm in length and 3 to 4 kg. The hind leg of the bird was devoid of flesh, but the cartilage and ligaments were intact. The only birds observed in the area with legs of similar size were Oldsquaw (*Clangula hyemalis*).

The lemming was only partially digested, suggesting that it was a recent capture: it was estimated to weigh 40 to 60 g. It had a complete brown summer pelage, supporting data that show changes in coat colour in this species are controlled by photoperiod and not temperature or persistence of snow cover (Mallory et al. 1981). Bifid claws (Hansen 1957), although considerably worn, were also present in this specimen suggesting that the change from the winter bifid claw structure to the summer form is not synchronized with coat colour. Small mammal trapping during July 1985 indicated that the microtine populations in this region were at peak numbers, and we speculate that occurrences of Lake Trout predation on lemmings may be more prevalent during years of high microtine density.

Although no information was found on swimming in the Collared Lemming, the large amount of water

associated with the arctic tundra suggests that the ability to swim may be important. Studies on other microtines, notably *Microtus*, indicate that they readily enter water and swim competently (Blair 1939; Peterson 1947; Murie 1960). Such behaviour would expose this species to predation by fish and other aquatic predators. Dunbar and Hildebrand (1952) and Harper (1961) have noted that mice and shrews are often eaten by Lake Trout.

Literature Cited

- Blair, W. F. 1939. A swimming and diving meadow vole. *Journal of Mammalogy* 20: 297-300.
- Dunbar, M. J., and H. H. Hildebrand. 1952. Contribution to the study of fishes of Ungava Bay. *Journal of the Fisheries Research Board of Canada* 9: 83-128.
- Hansen, R. M. 1957. Remarks on the bifid claws of varying lemmings. *Journal of Mammalogy* 38: 127-128.
- Harper, F. 1961. Field and historical notes on fresh-water fishes of the Ungava Peninsula and on certain marine fishes of the north shore of the Gulf of St. Lawrence. *Journal of Elisha Mitchell Science Society* 77: 312-342.
- Mallory, F. F., J. R. Elliott, and R. J. Brooks. 1981. Changes in body size in fluctuating populations of the collared lemming: age and photoperiod influences. *Canadian Journal of Zoology* 59: 174-182.
- Murie, A. 1960. Aquatic voles. *Journal of Mammalogy* 41: 273-275.
- Peterson, R. L. 1947. Further observations on swimming and diving of meadow voles. *Journal of Mammalogy* 19: 297-298.
- Weichert, C. K. 1951. *Anatomy of chordates*. Fourth edition. McGraw-Hill Book Company, Toronto, Ontario. 814 pp.

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The Range of the Yellow-spotted Salamander, *Ambystoma maculatum*, in Northern Ontario

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Weller, Wayne F. 1987. The range of the Yellow-spotted Salamander, *Ambystoma maculatum*, in northern Ontario. Canadian Field-Naturalist 101(3): 452-453.

A re-evaluation of records of the Yellow-spotted Salamander, *Ambystoma maculatum*, in northern Ontario rejects two previously published localities and restricts its known distribution south of a line about 150 km inland of the Great Lakes from North Bay in the east, to Lake Nipigon in the north and to Atikokan in the west.

Key Words: Yellow-spotted Salamander, *Ambystoma maculatum*, northern Ontario, distribution.

The most recent documentation of records of the Yellow-spotted Salamander, *A. maculatum*, in Ontario (Logier and Toner 1961) indicated that this species occurs north (from west to east) to Atikokan (49°46'N), Lake Nipigon (50°40'N), Kapuskasing (50°26'N), and Lake Temagami (47°00'N). These records were the basis, in part, for the range mapped in Anderson (1967), Conant (1975), and Cook (1984). New collections prompted a review of previous reports and a re-examination of museum specimens from north of the Sudbury and North Bay areas (46°26'N). Five reports were found to be unsubstantiated or based on misidentifications; their deletion and new records presented here redefine the known northern limit.

Two published records (numbered squares, Figure 1) are apparently based on misidentifications:

1. Kapuskasing, Cochrane District. Reported in Logier and Toner (1961) on the basis of three larvae (Royal Ontario Museum 3745-47) collected 18 July 1933. Only one of these specimens (ROM 3745) currently exists in the ROM collection. This larva (23.5 mm snout-vent length; 35 mm total length) when compared to keys in Orton (1939), Brandon (1964), Altig and Ireland (1984), and the dentition drawings in Bishop (1941), more closely resembles larvae of the *A. jeffersonium* complex than it does larval *A. maculatum* and is therefore probably *A. laterale*, the only species in the complex at this latitude. This identification was independently confirmed by R. A. Brandon and M. Morris.

2. Lake Temagami, Nipissing District. Reported in Coventry (1931: 109) who had found "... spawn at the heads of swampy bays that seems certainly to belong to this species [*Ambystoma maculatum*]..." Coventry further commented "I have not found the metamorphosed animal", but that its presence was "supported by specimens in the Royal Ontario Museum of Zoology". There are, however, no collections of *A. maculatum* eggs from this area in the

ROM, and the only collection of *Ambystoma* salamanders from Lake Temagami attributed to Coventry are five juvenile *A. laterale* (ROM 1069-73) taken in 1929.

A. maculatum is listed in a few manuscript reports for northern Ontario revealed in a search of the Ontario Ministry of Natural Resources files; West Patricia Planning Area (top left corner, Figure 1), Kenora District (Anonymous. 1978. Reptiles and amphibians of the West Patricia Planning Area. Northwestern region, Kenora, Ontario. 1 p.); Missinaibi River Park Reserve (75 km north of Locality 7, Figure 1), Sudbury District (G. A. Shea. 1977. Life Science Survey of Missinaibi River Park Reserve. Northern Region, Sudbury, Ontario. 385 pp.); and Greenwater Provincial Park (200 km northeast of Locality 7), Cochrane District (D. L. Culm. 1977. Life Science Inventory: Greenwater Provincial Park. Environmental Planning Series 8(5). Life Science Report. OMNR Division of Parks, Queen's Park, Toronto 193 pp.). None of these reports can be confirmed by specimens or photographs, and the known authors have not responded to enquiries. Clearly these can not be used to evaluate distribution and may be speculative inclusions based on previous range maps.

The following are confirmed records. All are of transformed individuals with readily distinguishable yellow spots and are plotted in Figure 1 as numbered triangles (published) and circles (unpublished).

1. Rainy River District, Atikokan. Observation made during 1955-61 (A. F. Helmsley, confirmed in personal communication to WFW, 17 December 1984), and reported in Logier and Toner (1961).

2. Thunder Bay District, Dog River, 40 km north of Thunder Bay. Sighting in June 1975 by D. Gregory (personal communication to WFW, 13 December 1984) of one on Hwy 527. 3. Thunder Bay District, Lake Nipigon, Shakespeare Island. 25 June 1926. ROM 1016 (1 specimen), reported in Logier (1928)

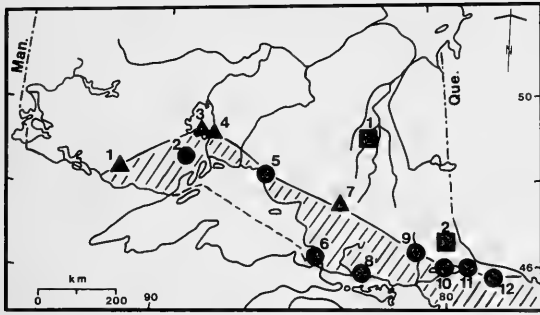


FIGURE 1. Localities for Yellow-spotted Salamanders, *Ambystoma maculatum*, in northern Ontario. Triangles: confirmed records published in Logier and Toner (1961), circles: recent valid records, squares: records included by Logier and Toner (1961) which are now discounted, and cross-hatching: the probable range. Numbers reference localities discussed in the text.

and Logier and Toner (1961). 4. Thunder Bay District, Fairlock. 7, 8, 30 June 1922. ROM 1011-13 (3) reported in Logier (1928) and Logier and Toner (1961). 5. Thunder Bay District, Pukaskwa National Park, Cave Harbour. Park photograph (D203), examined by WFW, of an individual observed on 22 May 1975 (R. Hamilton, personal communication, 12 January 1983). 6. Algoma District, 2.8 km east of Gros Cap. 10 May 1982. W. F. Weller. National Museums of Canada (NMC) 26329(1). 7. Sudbury District, Chapleau. Received at ROM 8 September 1948. ROM 7457-58(2). Reported in Logier and Toner (1961) but not mapped. 8. Algoma District, 1.6 km east of Algoma Mills. 2 May 1965. F. R. Cook and S. W. Gorham. NMC 8398(3). 9. Sudbury District, 28 km northeast of Sudbury. 20 April 1984. W. F. Weller, ROM H12568(1). 10. Nipissing District, Lake Nipissing, Iron Island. 22 August 1932. ROM 3320(1). 11. Nipissing District, north of Bonfield. 1 May 1965. F. R. Cook and S. W. Gorham. NMC 8394(10). 12. Nipissing District, Dorami Lake. A. Beck. 9 May 1965. NMC 9065(1).

The known northern distribution of *A. maculatum* in Ontario, with the Kapuskasing and Lake Temagami records deleted, does not extend beyond the height of land separating the Great Lakes drainage from that of Hudson Bay. In Quebec the most northern record is near Chibougamau (49° 54'N,

74° 15'W) at the James Bay-St. Lawrence drainage divide (Gordon and Cook 1980).

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Literature Cited

- Altig, R., and P. H. Ireland. 1984. A key to salamander larvae and larviform adults of the United States and Canada. *Herpetologica* 40(2): 212-218.
- Anderson, J. D. 1967. *Ambystoma maculatum*. Pp. 51.1-51.4 in Catalogue of American amphibians and reptiles. American Society of Ichthyologists and Herpetologists, Bethesda, Maryland.
- Bishop, S. C. 1941. The salamanders of New York. New York State Museum Bulletin Number 324. 365 pp.
- Brandon, R. A. 1964. An annotated and illustrated key to multistage larvae of Ohio salamanders. *The Ohio Journal of Science* 64(4): 252-258.
- Conant, Roger. 1975. A field guide to reptiles and amphibians of eastern and central North America. Houghton Mifflin Company, Boston, Massachusetts.
- Cook, F. R. 1984. Introduction to Canadian amphibians and reptiles. National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario, Canada. 200 pp.
- Coventry, A. F. 1931. Amphibia, reptilia and mammalia of the Temagami District, Ontario. *Canadian Field-Naturalist* 45(5): 109-113.
- Gordon, David M., and Francis R. Cook. 1980. Range extension for the Yellow-spotted Salamander, *Ambystoma maculatum*, in Quebec. *Canadian Field-Naturalist* 94(4): 460.
- Logier, E. B. S. 1928. The amphibians and reptiles of the Lake Nipigon region. *Transactions of the Royal Canadian Institute* 16(2): 279-291.
- Logier, E. B. S., and G. C. Toner. 1961. Checklist of the amphibians and reptiles of Canada and Alaska. Royal Ontario Museum Life Sciences Division Contribution 53. 92 pp.
- Orton, G. 1939. Key to New Hampshire amphibian larvae. New Hampshire Fish and Game Department Survey Report Number 4: 218-221.

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Influence of an Unidentified Epornitic on Waterfowl Nesting at Jessie Lake, Alberta

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Lesser Scaup (*Aythya affinis*) and Gadwall (*Anas strepera*) nesting ecology was studied on Jessie Lake, Alberta (54°10'N, 110°04'W) during the summers of 1975 and 1976. High nest densities were found in both years, and nest success was high (74% for Lesser Scaup, 93% for Gadwall) in 1975. In 1976, an unidentified epornitic reduced nest success 49% for Lesser Scaup and 35% for Gadwall by killing incubating females or causing nest abandonment. Waterfowl management activities that increase densities of nesting waterfowl to levels similar to those on Jessie Lake may increase the chance of high mortality from disease.

Key Words: *Aythya affinis*, Lesser Scaup, *Anas strepera*, Gadwall, brood production, epornitic, clutch size, nest success, island nesting, Alberta.

Waterfowl often nest in high concentrations on islands (Hammond and Mann 1956; Hildén 1965; Duebbert 1966; Vermeer 1968; Drewien and Fredrickson 1970; Duebbert et al. 1983). High densities and nest success (i.e. > 60%) are usually attributed to reduced mammalian predation (Hammond and Mann 1956; Hildén 1965; Vermeer 1970; Ewaschuk and Boag 1972). Island nesting populations may increase rapidly if females that successfully nested in previous years and their female offspring return to the same nesting area.

Island construction is a common practice in waterfowl management because it encourages high densities of nesting waterfowl (Hammond and Mann 1956; Keith 1961; Mihelsons et al. 1967; Sherwood 1968; Bellrose and Low 1978; Giroux 1981; Willms 1985). The potential for increasing nesting densities of waterfowl is real, but one disadvantage is the greater potential of mortality from disease. Disease outbreaks among waterfowl during breeding have been reported for several species and locations (Gershman et al. 1964; Hanson and Willis 1977; Wobeser et al. 1979; Korschgen et al. 1978), but little is known about disease effects on nest success and brood production. The purpose of this paper is to report the effects of an epornitic on Lesser Scaup and Gadwall nesting success and brood production at Jessie Lake, Alberta in 1976.

Methods

Intensive nest searches were conducted on the two islands (each 1 ha) in Jessie Lake, Alberta, between 25 June and 31 July, 1975, and between 3 June and 31 July, 1976. Both islands were searched twice each year. Camouflaged wood markers were placed 5 m

north of each nest, and the species, number of eggs, and stage of incubation (Weller 1956) were recorded. The location of each nest was recorded on detailed cover maps. Nests were revisited within 5 days of the projected hatching date, and the fate of the clutch was determined by the presence or absence of shell membranes and the appearance of the nest (Broley 1950). Nests were considered successful if one egg hatched. The modified Mayfield method for calculating nest success (Miller and Johnson 1978) was not used because nearly all nests on these small islands were found early in incubation. *T*-tests were used to detect statistical differences (0.05 level of significance).

Pair and brood censuses were conducted on days with low winds (< 5 km/hr) by systematically counting birds, from shore when possible and from a canoe for areas not visible from shore. Five pair counts were conducted from 31 May to 8 June, 1976, between 0600 h and 1000 h. Pairs, lone males, and lone females were counted as indicated pairs. Five brood counts were conducted from 0600 h to 1100 h between 1 July and 15 August in both years. Ducklings were classified by species and age. Brood counts were discontinued when 30% or more of ducklings reached the class III age (Gollop and Marshall 1954).

Results and Discussion

Gadwall and Lesser Scaup were the most numerous nesting waterfowl (60 nests/ha in 1975, and 106 nests/ha in 1976) (Table 1). White-winged Scoter (*Melanitta fusca*) nests were common (10.5 nests/ha in 1975; 13.8 nests/ha in 1976) [Brown and Brown 1981]. Low numbers (< 5 nests) of Blue-winged Teal (*Anas*

TABLE 1. Egg success and duckling survival for Lesser Scaup and Gadwall on Jessie Lake, Alberta, 1975–1976.

	Lesser Scaup		Gadwall	
	1975	1976	1975	1976
Number of nests	90	145	42	89
Mean clutch size	11.8	10.0	9.4	9.9
Mean number of eggs hatched in successful nests	8.9	8.8	9.5	9.6
Maximum number of ducklings	417	320	96	77
Number observed in last brood count	221	249	50	44

discors), Northern Shoveler (*Anas clypeata*), Pintail (*Anas acuta*), Mallard (*Anas platyrhynchos*), American Wigeon (*Anas americana*), and Green-winged Teal (*Anas crecca*) also were found each year. One Common Crow (*Corvus brachyrhynchos*) nest was found each year on one island.

The greater numbers of nests found in 1976 probably reflected earlier nest searching activities rather than an increase in the number of nests (Table 1). In 1975, some nests had hatched before we finished nest searching. Mean clutch size and mean number of eggs hatched in successful nests did not change significantly between years ($P > 0.10$). Increased intraspecific strife resulting from crowding, as reported in North Dakota (Duebbert et al. 1983), was not observed.

The mean number of indicated pairs (\pm 95% CI) was 169 ± 23 for Lesser Scaup, and 38 ± 22 for Gadwall. The number of pairs observed on Jessie Lake corresponded closely to the number of Lesser Scaup nests found on the islands, but was less than half the number of Gadwall nests. Evidently, Gadwall females tended to leave Jessie Lake to feed and conduct other activities, and used the lake mainly for nesting habitat, as reported elsewhere (Gates 1962; Duebbert 1966; Duebbert et al. 1983).

In 1976, 12 female Lesser Scaup and 6 female Gadwall were found dead on or near the nest between 10 and 15 June. No disease was positively diagnosed in six recently dead birds submitted to provincial authorities. Botulism was suspected for three of the birds, but results were inconclusive (Murray Busch, Alberta Department of Energy and Natural Resources, personal communication). Conditions on Jessie Lake were similar to those commonly reported for botulism outbreaks (hot temperatures and low wind that produces stagnant water) [Bellrose 1980:69]. Some Gadwall on the lake showed symptoms of botulism (Bellrose 1980:68), but this evidence was not considered conclusive.

Rates of nest success for Gadwall in 1975 were similar to rates for North Dakota islands sites (Duebbert 1966; Duebbert et al. 1983). Lesser Scaup nest success was lower in 1975 than reported by Vermeer (1968) in Alberta and by Hines (1977) in Saskatchewan. Success rates were reduced for both species in 1976 (Table 2). White-winged Scoter nest success in 1976 was only slightly less than in 1975 (Brown and Brown 1981). Assuming that the 1975 and 1976 rates of nest success would have been similar in the absence of the epornitic, nest success rates were reduced by 49% for Lesser Scaup and 35% for Gadwall in 1976. The deaths of incubating females or nest abandonments by sick females in 1976 greatly increased the vulnerability of nests to avian predators, particularly crows.

The maximum number of ducklings on the lake was 23% lower for Lesser Scaup and 20% lower for Gadwall in 1976 than in 1975 (Table 1). The number of ducklings observed in the last brood count in 1976 was 13% higher than in 1975 for Lesser Scaup, and 12% lower for Gadwall. These results were difficult to interpret because broods could have moved overland from nearby wetlands to Jessie Lake as less permanent wetlands dried up. The maximum number of ducklings probably was less influenced by brood immigration onto Jessie Lake because this figure was recorded early in the brood season (31 May for Gadwall and 1 June for Lesser Scaup), and less brood movement had occurred away from dried wetlands. Based upon the maximum number of ducklings observed on the lake, brood production may have been reduced by the unidentified disease by approximately 20–23% for both Lesser Scaup and Gadwall compared with 1975 estimates.

Although intensive management of waterfowl may call for increased densities of waterfowl on available habitat, the risk of significant loss to disease and predation may be increased. Monitoring of management areas for evidence of disease outbreaks coupled with a rapid management response to minimize losses if an outbreak occurs (e.g. dispersal of nesting birds away from the area, manipulating water

TABLE 2. Fates of Lesser Scaup and Gadwall nests on Jessie Lake, Alberta, 1975–1976.

	Lesser Scaup				Gadwall			
	1976		1976		1975		1976	
	N	%	N	%	N	%	N	%
Successful	67	74	55	38	39	93	53	60
Abandoned	10	11	15	10	2	5	7	8
Destroyed	13	14	75	52	1	2	29	33

levels) may be necessary to protect local breeding populations.

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Literature Cited

- Bellrose, F. C.** 1980. Ducks, geese, and swans of North America. Third edition. The Wildlife Management Institute, Washington, DC, and Stackpole Books, Harrisburg, Pennsylvania. 540 pp.
- Bellrose, F. C., and J. B. Low.** 1978. Advances in waterfowl management research. *Wildlife Society Bulletin* 6: 63-72.
- Broley, J.** 1950. Identifying nests of the Anatidae of the Canadian prairies. *Journal of Wildlife Management* 14: 452-456.
- Brown, P. W., and M. A. Brown.** 1981. Nesting biology of the White-winged Scoter. *Journal of Wildlife Management* 45: 38-45.
- Drewien, R. C., and L. H. Fredrickson.** 1970. High density Mallard nesting on a South Dakota island. *Wilson Bulletin* 82: 95-96.
- Duebbert, H. F.** 1966. Island nesting of the Gadwall in North Dakota. *Wilson Bulletin* 78: 12-25.
- Duebbert, H. F., J. T. Lokemoen, and D. E. Sharp.** 1983. Concentrated nesting of Mallards and Gadwalls on Miller Lake Island, North Dakota. *Journal of Wildlife Management* 47: 729-740.
- Ewaschuk, E., and D. A. Boag.** 1972. Factors affecting hatching success of densely nesting Canada Geese. *Journal of Wildlife Management* 36: 1097-1106.
- Gates, J. M.** 1962. Breeding biology of the Gadwall in northern Utah. *Wilson Bulletin* 74: 43-67.
- Gershman, M., J. F. Witter, H. E. Spencer, Jr., and A. Kalvaitis.** 1964. Case report: epizootic of fowl cholera in the Common Eider Duck. *Journal of Wildlife Management* 28: 587-589.
- Giroux, J.-F.** 1981. Use of artificial islands by nesting waterfowl in southeastern Alberta. *Journal of Wildlife Management* 45: 669-679.
- Gollop, J. B., and W. H. Marshall.** 1954. A guide for aging duck broods in the field. Mississippi Flyway Council Technical Section. 14 pp.
- Hammond, M. C., and G. E. Mann.** 1956. Waterfowl nesting islands. *Journal of Wildlife Management* 20: 345-352.
- Hanson, J. A., and N. G. Willis.** 1977. An outbreak of duck virus enteritis (duck plague) in Alberta. *Journal of Wildlife Diseases* 12: 258-262.
- Hildén, O.** 1965. Habitat selection in birds. A review. *Zoologica Fennica* 2: 53-75.
- Hines, J. E.** 1977. Nesting and brood ecology of Lesser Scaup at Waterhen Marsh, Saskatchewan. *Canadian Field-Naturalist* 91: 248-255.
- Keith, L. B.** 1961. A study of waterfowl ecology on small impoundments in southeastern Alberta. *Wildlife Monograph* Number 6. 88 pp.
- Korschgen, C. E., H. C. Gibbs, and H. L. Mendall.** 1978. Avian cholera in Eider Ducks in Maine. *Journal of Wildlife Diseases* 14: 254-258.
- Mihelsons, H., J. Viksne, and G. Lejins.** 1967. Experience in waterfowl management under the conditions prevailing in the Latvian S.S.R. *Wildfowl* 18: 146-149.
- Miller, H. W., and D. H. Johnson.** 1978. Interpreting the results of nesting studies. *Journal of Wildlife Management* 42: 471-476.
- Sherwood, G. A.** 1968. Factors limiting production and expansion of local populations of Canada Geese. Pages 73-85 in *Canada Goose management*. Edited by R. L. Hine and C. Schoenfeld. Dembar Educational Research Service, Madison, Wisconsin. 195 pp.
- Vermeer, K.** 1968. Ecological aspects of ducks nesting in high densities among larids. *Wilson Bulletin* 80: 78-83.
- Vermeer, K.** 1970. Breeding biology of California and Ring-billed Gulls: a study of ecological adaptation to the inland habitat. *Canadian Wildlife Service Report Series* Number 12.
- Weller, M. W.** 1956. A simple field candler for waterfowl eggs. *Journal of Wildlife Management* 20: 111-113.
- Willms, M. A.** 1985. Utilization of nesting islands by waterfowl in North Dakota. M.S. thesis, University of North Dakota, Grand Forks, North Dakota. 68 pp.
- Wobeser, G., D. B. Hunter, B. Wright, D. J. Nieman, and R. Ibister.** 1979. Avian cholera in waterfowl in Saskatchewan, Spring 1977. *Journal of Wildlife Diseases* 15: 19-24.

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Summer Spawning in the Fourhorn Sculpin, *Myoxocephalus quadricornis*, from Alaska

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Goldberg, Stephen R., William T. Yasutake, and Robin L. West. 1987. Summer spawning in the Fourhorn Sculpin, *Myoxocephalus quadricornis*, from Alaska. Canadian Field-Naturalist 101(3): 457.

Histological ovarian analysis indicates summer spawning occurs in *Myoxocephalus quadricornis* (Fourhorn Sculpin) from Alaska. Previous studies have shown this species spawns during winter in the Baltic Sea; the data presented herein suggests that geographical variation may occur in the timing of spawning of this species.

Key Words: Fourhorn Sculpin, *Myoxocephalus quadricornis*, summer spawning, Alaska.

The fourhorn sculpin, *Myoxocephalus quadricornis*, which inhabits cold, brackish and moderately saline water (Morrow 1980) has a circumpolar distribution. It is a common species in the Beaufort Sea (Craig 1984). In the Baltic Sea, spawning takes place from mid-December through January (Westin 1968, 1969). The purpose of this note is to provide histological information on the time of spawning for this fish in Alaska.

Sixteen fish (four females and twelve males) were collected using Fyke or gill nets from the Beaufort Lagoon (69°50'N, 142°15'W) Beaufort Sea, Alaska between 26 and 29 July 1984. Gonads were preserved in Bouin's fixative and embedded in paraffin. Histological sections were cut at 5 μ m and stained with Harris' hematoxylin followed by eosin counterstain. Ages were estimated by reading otoliths.

Histological ovarian analysis indicates that summer spawning activity occurs in *M. quadricornis*. Three of four females examined contained hydrated eggs. These fully hydrated eggs averaged 728 μ m in diameter. During hydration the oocyte may enlarge as much as four times (Wallace and Selman 1980). Hydration occurs just prior to spawning. The three females with hydrated eggs were between 4 and 7 years of age and averaged 220 mm fork length (FL). One of these females also contained eggs with early yolk deposition. This suggests the possibility that some *M. quadricornis* may spawn more than once during a reproductive season in the Beaufort Sea. A fourth female contained vitellogenic eggs (yolk deposition in progress). It was between three and four years of age and measured 154 mm FL.

Histological analysis revealed eight of twelve males were undergoing sperm formation. These were between three and five years of age and averaged 160 mm FL. Four, presumably juvenile, males between two and three years of age contained

spermatogenic cysts in the testes but no sperm. The four juvenile males averaged 95 mm FL.

Previous work from the Baltic Sea off Sweden (Westin 1968, 1969) has shown *M. quadricornis* to be a winter spawner (December-January). Our work has indicated that *M. quadricornis* spawns during summer in northern Alaska. Therefore, our data have shown the possibility that geographic variation may exist in the timing of the reproductive cycle of this species. Subsequent studies will be required to determine the total length of the Beaufort Sea *M. quadricornis* spawning period as well as how many times a female spawns in a reproductive season.

Acknowledgments

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Literature Cited

- Craig, P. C. 1984. Fish use of coastal waters of the Alaskan Beaufort Sea: a review. Transactions of the American Fishery Society 113: 265-282.
- Morrow, J. E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Co., Anchorage. 248 pp.
- Wallace, R. A., and K. Selman. 1981. Cellular and dynamic aspects of oocyte growth in teleosts. American Zoologist 21: 325-343.
- Westin, L. 1968. Fertility of the fourhorn sculpin, *Myoxocephalus quadricornis* (L.). Reports of the Institute of Freshwater Research, Drottningholm 48: 67-70.
- Westin, L. 1969. The mode of fertilization, parental behaviour and time of egg development in fourhorn sculpin, *Myoxocephalus quadricornis* (L.). Reports of the Institute of Freshwater Research, Drottningholm 49: 175-182.

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Enterolith in the Rumen of a Moose, *Alces alces gigas*

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Hoefts, Manfred, and Philip Merchant. 1987. Enterolith in the rumen of a Moose, *Alces alces gigas*. Canadian Field Naturalist 101(3): 458-459.

An egg-shaped enterolith recovered from the rumen of a Moose and consisting largely of CaPO_4 , showed concentrically arranged, periodic deposits which may be annual rings.

Key Words: Moose, *Alces alces gigas*, enterolith, Yukon.

In October 1982 a Moose (*Alces alces gigas*) was shot in the Donjek River area of southwest Yukon. The hunter, Russell Dickson, discovered an egg-shaped enterolith in the rumen of this Moose, which he submitted to the Wildlife Branch for analyses. While these intestinal concretions have been documented for domestic animals, particularly horses (Merck Veterinary Manual 1979), we are not aware of any records for wild ungulates, specifically Moose.

The term "enterolith" refers to concretions in the intestinal tract, in which concentric deposits are laid down about some nucleus, which may be a swallowed foreign body. These must not be confused with the so-called "bezoar stones", well known from the European wildlife literature. Bezoar stones are intestinal

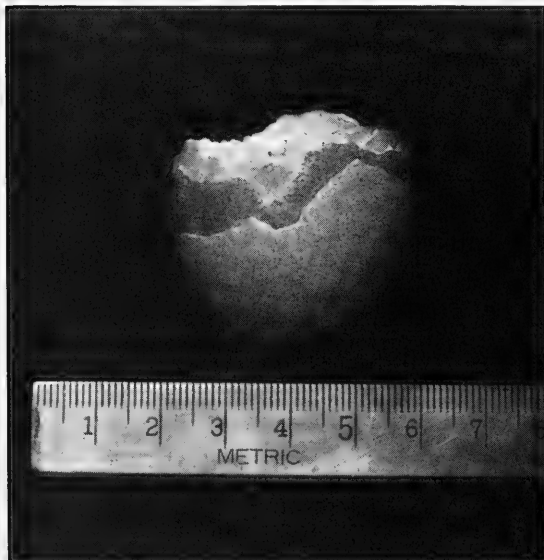


FIGURE 1. Side view of enterolith recovered from a Moose, showing shape of shells.



FIGURE 2. Cross-section of enterolith showing concentric deposits around molariform tooth.

accretions consisting of ingested, compacted hair, and are documented for wild goats and chamois (Knaus and Schröder 1960; Wetzel and Rieck 1962).

The enterolith has the shape of a flattened egg. Unfortunately, part of it was destroyed, allowing only an estimation of its total dimensions. The remaining intact part has a length of 42 mm, a width of 42 mm and a thickness of 28 mm (Figure 1). Assuming symmetrical growth, the total dimensions would have been 60 mm, 44 mm and 30 mm, respectively. The weight of the remaining part is 39 g, its volume 22 cm^3 and its density or specific gravity 1.8 g/cm^3 .

Of interest is the fact that the enterolith consists of eight shells. The average shell thickness is about 1 mm, but the first shells deposited are thicker than the last outer ones. The shells have been deposited

around a molariform tooth (Figure 2). This tooth is the deciduous PM2 of a Moose (Peterson 1955). The concentric deposits have a white matrix and an orange/brown-coloured outer surface. Chemical analyses carried out by X-Ray Assay Laboratories, Don Mills, Ontario, revealed that this growth consisted largely of CaPO_4 (90%), with traces of some 14 other elements, notably Mg, Na, K and Si.

We assume that the concentric deposits are annual growth increments that were laid down in a seasonal sequence similar to the periodic growth of the teeth and horns of northern bovids. The deciduous premolar, which served as the nucleus, becomes dislodged at about 1.5 years of age, and was inadvertently swallowed. Since the outer surface colour of this enterolith was dark, growth for the current season had already ceased or slowed down when the Moose was taken. The change in browse quality from summer to winter, or greatly reduced

feed intake during the rutting season in October, may be responsible for this periodic growth of the enterolith.

If this theory is valid, the Moose was about 9.5 years old when it died. Unfortunately, neither jaw nor antlers were brought out for age verification. All we know is that the Moose was an adult male.

Literature Cited

- Merck Veterinary Manual.** 1979. Merck & Co. Inc., Rahway, New Jersey.
Knaus, W., and W. Schröder. 1960. Das Gamswild. Verlag Paul Parey, Hamburg. 234 pp.
Peterson, R. L. 1955. North American Moose. University of Toronto Press, Toronto. 280 pp.
Wetzel, R., and W. Rieck. 1962. Krankheiten des Wildes. Verlag Paul Parey, Hamburg. 223 pp.

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Two sedges, *Carex conoidea* and *Carex gravida* (Cyperaceae), new to Manitoba

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Catling, P. M. 1987. Two sedges, *Carex conoidea* and *Carex gravida* (Cyperaceae), new to Manitoba. Canadian Field-Naturalist 101(3): 459-460.

The discovery of *Carex conoidea* Bailey in tallgrass prairie and of *Carex gravida* Schk. in the Souris River gallery forests near Stuartburn adds these species to the vascular plant flora of Manitoba.

Key Words: Cyperaceae, sedge, *Carex conoidea*, *Carex gravida*, floristics, new record, phytogeography, Manitoba.

Carex conoidea Schk.

Carex conoidea in the broad sense (including *C. katahdinensis*) is widespread in northeastern North America from Newfoundland to northwestern Ontario and south to southern Illinois and North Carolina (Ball et al. 1982). The discovery of this species in the tallgrass prairie near Stuartburn represents an addition to the flora of Manitoba. This location is also on the northwestern edge of the species range, and is ca. 40 km north of a location in Kittson Co., Minnesota (Wheeler and Ownbey 1984), and ca. 300 km west of the nearest Canadian location, which is in northwestern Ontario. Plants from northwestern Ontario are referable to *C. katahdinensis* in the strict sense. In Minnesota, *C. conoidea* and *C. katahdinensis*

are easily distinguished morphologically and ecologically (Wheeler and Ownbey 1984).

In the prairie near Stuartburn, *C. conoidea* was found in lower, more moist places dominated by graminoids including *Deschampsia caespitosa*, *Agrostis stolonifera*, *Carex praegracilis*, *Carex tetanica*, *Carex buxbaumii*, *Juncus balticus*, *Juncus dudleyi*, *Juncus longistylis*, *Muhlenbergia richardsonis*, and *Eleocharis elliptica*. Shrubs including willow (*Salix petiolaris*), Shrubby Cinquefoil (*Potentilla fruticosa*) and Dwarf Birch (*Betula glandulosa*) were also prominent in the area.

Carex conoidea is distinctive among Manitoba sedges in its beakless, rounded perigynia with impressed nerves. The specimen cited below has a

long-peduncled, staminate spike and is consequently *Carex conoidea sensu stricto*, rather than *C. katahdinensis*.

Specimens examined: MANITOBA: 1.5 miles (2.4 km) east of Stuartburn, north side of hwy. 201, UTM 654448, 10 July 1985, *P. M. Catling s.n.* (DAO)

Carex gravida Bailey

A species with a broad midwestern distribution (see Ball et al. 1982), *Carex gravida* is known in Canada from southeastern Saskatchewan (Hudson 1977; Maher et al. 1979) and southwestern Ontario (Ball et al. 1982). It is rare in both provinces. *Carex gravida* was not listed for Manitoba by Scoggan (1957), but it was later reported in the Otterburne area (Love and Bernard 1959; repeated by Scoggan 1978). This report, however, was discounted by Boivin (1979) and by White and Johnson (1980) since the voucher proved to be referable to *C. alopecoidea* Tuckerm. I have examined this voucher (St. Pierre, bord du Chemin, 24 juillet 1954, *J.-P. Bernard* 289 (DAO, QFA) and I agree that it is referable to *C. alopecoidea*.

During a brief survey of the Souris River gallery forests between Melita and a point 6 km north of Coulter in southwestern Manitoba, I found *Carex gravida* in two locations. The plants occurred in closed to semi-open Burr Oak (*Quercus macrocarpa*) – Manitoba Maple (*Acer negundo*) woodland with scattered shrubs of Saskatoon-berry (*Amelanchier alnifolia* var. *alnifolia*). The herb layer was dominated by other sedges (including *Carex assiniboinensis*, *C. sprengelii*, *C. backii* var. *saximontana*, and *C. laeviconica*). Similar woodland habitats are reported for Saskatchewan (Maher et al. 1979; J. H. Hudson, personal communication), and suggest that the reference to "prairies, swamps and shores" by Scoggan (1978) is not representative of the species, at least not in Canada. *Carex gravida* was sporadic at the two locations with a total of only 10 plants found.

The plants from Melita have the relatively wide leaves (some over 5 mm) and relatively long ligule of var. *lunelliana* (Mack.) Hermann. However, the pistillate scales are strongly awned, and the perigynia have teeth 0.6–0.9 mm long, an ovate body, and are not strongly ribbed. Thus the plants seem best placed with var. *gravida*. Perigynia characters could be evaluated with confidence in only four perigynia,

since most perigynia were infected by chalcid wasp larvae, and such infections may alter shape and venation.

Carex gravida is distinctive among Manitoba sedges in the following character combination: loose, white sheaths with green veins and green mottling, leaves 3–6 mm wide, spikelets crowded in a dense inflorescence, and pistillate scales with awned tips. *Carex gravida* resembles *C. alopecoidea*, but differs in lacking the strongly winged culms and in having a densely crowded inflorescence; the lower spikes of *C. alopecoidea* are distinct and separate.

Specimens examined: MANITOBA: 14 km south of Melita, UTM 14V-LK-536462, 9 July 1985, *P. M. Catling* 5501 (DAO, MICH, MMMN). 6 km NNE of Coulter at Coulter Park, UTM 14V-LK-535445, 19 July 1985, *P. M. Catling* 5620 (DAO).

Literature Cited

- Ball, P. W., D. J. White, P. M. Catling, A. A. Reznicek, and B. Boivin. 1982. Rare species of Cyperaceae in Atlas of the rare vascular plants of Ontario. Edited by G. W. Argus and D. J. White. National Museum of Natural Sciences.
- Boivin, B. 1979. Flora of the prairie provinces. Part IV — Monopsida. *Provancheria* 5. 198 pp.
- Hudson, J. H. 1977. *Carex* in Saskatchewan. Bison Publishing House, Saskatoon, Saskatchewan. 193 pp.
- Love, D., and J.-P. Bernard. 1959. Flora and vegetation of the Otterburne area, Manitoba, Canada. *Svensk Botanisk Tidskrift* 53(4): 335–461.
- Maher, R. V., G. W. Argus, V. L. Harms, and J. H. Hudson. 1979. The rare vascular plants of Saskatchewan. *Syllogeus* (National Museum of Natural Sciences), 20. 55 pp + maps.
- Scoggan, H. J. 1957. Flora of Manitoba. *National Museum of Canada Bulletin* 140. 619 pp.
- Scoggan, H. J. 1978. The flora of Canada, part 2 — Pteridophyta, Gymnospermae, Monocotyledonae. *National Museum of Natural Sciences, Publications in Botany* 7(2): 93–545.
- Wheeler, G. A., and G. B. Ownbey. 1984. Annotated list of Minnesota Carices, with phytogeographical and ecological notes. *Rhodora* 86: 151–238.
- White, D. J., and K. L. Johnson. 1980. The rare vascular plants of Manitoba. *Syllogeus* 27 (National Museum of Natural Sciences). 52 pp + maps.

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Observations on Cranial Differences Between Juvenile and Adult Eastern Coyotes, *Canis latrans*

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Moore, Gary C., and John S. Millar. 1987. Observations on cranial differences between juvenile and adult eastern Coyotes, *Canis latrans*. Canadian Field-Naturalist 101(3): 461-463.

Analysis of cranial measurements of a sample of Coyotes, *Canis latrans*, from New Brunswick and Nova Scotia suggests that juvenile (<one year old) skulls more closely resemble typical western Coyote skulls than do adult (>one year old) skulls. It appears that the cranial features characteristic of eastern Coyotes are acquired during the latter stages of cranial growth.

Key Words: Coyote, *Canis latrans*, cranial differences, New Brunswick, Nova Scotia.

A study of the eastern Coyote, *Canis latrans*, in New Brunswick and Nova Scotia (Moore 1981) necessitated the collecting of carcasses (largely from trappers) during October through January of 1979-1980 and 1980-1981. To ensure that no domestic dogs, *Canis familiaris*, or Coyote-dog hybrids occurred in this sample, all intact skulls were cleaned and analyzed according to the method of Lawrence and Bossert (1967, 1969). Their method used a form of linear discrimination of fifteen cranial measurements to identify Coyote, dog, and Wolf, *Canis lupus*, skulls based on paired comparisons. Each measurement was divided by total skull length; these ratios were then multiplied by a series of pre-defined discriminant coefficients which varied with the comparison being made, the result being a weighted sum called a discriminant function. By utilizing two comparisons (e.g. Coyote-dog and Coyote-Wolf discriminations), it was possible to plot the discriminant function values of individual skulls and graphically illustrate a general "range" of known species skulls (Figure 1).

Although Lawrence and Bossert (1967, 1969) examined only adult skulls, both juvenile (<one year old) and adult (>one year old) skulls were measured in the present study. Age identification was accomplished by examining cementum annuli on the canine root tip (Johnston 1975) of all skulls which could not be directly assigned to the juvenile cohort based on incomplete closure of the canine root tip (Linhart and Knowlton 1967; Allen and Kohn 1976).

It was apparent during the present analysis that cursory examination of the skulls prior to measurement could identify dog-like specimens, based on such characteristics as the ratio of total length to zygomatic breadth, ratio of palatal width to length of upper molar tooth row, width of rostrum, height of frontal shield and inflation of frontal sinuses, and size of

brain case, auditory bullae and teeth (Hall 1943; Howard 1949; Lawrence and Bossert 1967, 1969; Richens and Hugie 1974; Hilton 1976).

Additionally, juvenile eastern Coyote skulls appeared to be more "slender" than adult eastern Coyote skulls, and thus more closely resembled typical western Coyote skulls. Despite the lack of a linear discrimination designed specifically to illustrate differences between juvenile and adult skulls, this differentiation can be detected in the position of juvenile and adult skulls along the *latrans-lupus* discriminant function axis (Figure 1). Juvenile eastern Coyotes have a general tendency towards the known range of western Coyotes, while adults have a tendency towards the known range of Wolves. The wide variation in the position of juvenile eastern Coyote skulls along this axis is probably a reflection of the different stages of cranial development encountered during the October through January collecting period; those juveniles having cranial characteristics similar to adults were probably collected during the latter stages of development.

The relatively large size of eastern Coyotes has prompted considerable speculation regarding their genetic origin (Lawrence and Bossert 1969; Silver and Silver 1969; Mengel 1971; Bekoff et al. 1975; Hilton 1976, 1978; Bekoff 1978). From the current observations it appears that the widely reported dog-like and/or Wolf-like cranial characteristics of eastern Coyote skulls are acquired during the latter stages of cranial growth.

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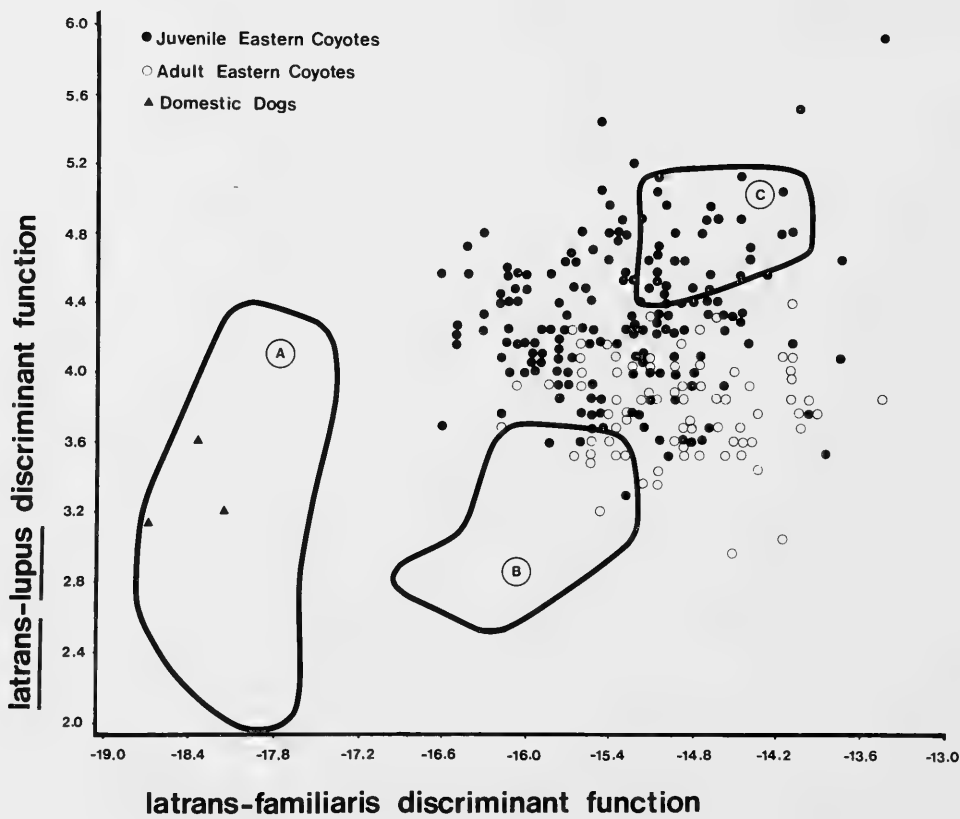


FIGURE 1. Plot locations of the eastern Coyote and domestic dog skulls measured during the current study. Solid lines indicate the approximate ranges of known species skulls (A = domestic dogs, B = Wolves, C = western Coyotes), taken from Lawrence and Bossert (1969).

Museum) arranged for the cleaning of a portion of the skulls. L. M. J. N. El-Khoury (New Brunswick Department of Natural Resources) prepared the figure. The New Brunswick Department of Natural Resources and the Nova Scotia Department of Lands and Forests aided in the collection of carcasses and provision of logistic support. The trappers of New Brunswick and Nova Scotia are thanked for their support of this project.

Literature Cited

- Allen, S. H., and S. C. Kohn. 1976. Assignment of age-classes in coyotes from coyote cementum annuli. *Journal of Wildlife Management* 40(4): 796-797.
- Bekoff, M. 1978. Behavioral development in coyotes and eastern coyotes. Pages 97-126 in *Coyotes: biology, behavior, and management*. Edited by M. Bekoff. Academic Press, New York, New York. 384 pp.

- Bekoff, M., H. L. Hill, and J. B. Mitton. 1975. Behavioral taxonomy in canids by discriminant function analyses. *Science* 190: 1223-1225.
- Hall, E. R. 1943. Cranial characters of a dog-coyote hybrid. *American Midland Naturalist* 29(2): 371-374.
- Hilton, H. 1976. The physical characteristics, taxonomic status, and food habits of the eastern coyote in Maine. M.Sc. thesis, University of Maine, Orono, Maine. 67 pp.
- Hilton, H. 1978. Systematics and ecology of the eastern coyote. Pages 209-228 in *Coyotes: biology, behavior, and management*. Edited by M. Bekoff. Academic Press, New York, New York. 384 pp.
- Howard, W. E. 1949. A means to distinguish skulls of coyotes and domestic dogs. *Journal of Mammalogy* 30(2): 169-171.
- Johnston, D. H. 1975. The significance of von Ebner's lines as daily increments of growth in the dentin of carnivores. Oravax Progress Report 1974-1975, Number 1. Presented at Coyote Symposium, 1975 Northeast Fish and Wildlife Conference. 10 pp.

- Lawrence, B., and W. H. Bossert. 1967. Multiple character analysis of *Canis lupus*, *latrans*, and *familiaris*, with a discussion of the relationships of *Canis niger*. *American Zoologist* 7: 223–232.
- Lawrence, B., and W. H. Bossert. 1969. The cranial evidence for hybridization in New England *Canis*. *Breviora* 330: 1–13.
- Linhart, S. B., and F. F. Knowlton. 1967. Determining age of coyotes by tooth cementum layers. *Journal of Wildlife Management* 31(2): 362–365.
- Mengel, R. M. 1971. A study of dog-coyote hybrids and implications concerning hybridization in *Canis*. *Journal of Mammalogy* 52(2): 316–336.
- Moore, G. C. 1981. A comparative study of colonizing and longer established eastern coyote (*Canis latrans* var.) populations. M.Sc. thesis, The University of Western Ontario, London, Ontario. 124 pp.
- Richens, V. B., and R. D. Hugie. 1974. Distribution, taxonomic status, and characteristics of coyotes in Maine. *Journal of Wildlife Management* 38(3): 447–454.
- Silver, H., and W. T. Silver. 1969. Growth and behavior of the coyote-like canid of northern New England with observations on canid hybrids. *Wildlife Monograph* 17. 41 pp.

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Field Observations of Summer and Autumn Spawning by *Strongylocentrotus droebachiensis*, Green Sea Urchins, in Eastern Newfoundland¹

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Keats, D. W., R. G. Hooper, D. H. Steele, and G. R. South. 1987. Field observations of summer and autumn spawning by *Strongylocentrotus droebachiensis*, Green Sea Urchins, in eastern Newfoundland. *Canadian Field-Naturalist* 101(3): 463–465.

Summer spawning of Green Sea Urchins, *Strongylocentrotus droebachiensis*, was directly observed on four separate occasions on the coast of eastern Newfoundland.

Key Words: *Strongylocentrotus droebachiensis*, Green Sea Urchin, delayed spawning, Newfoundland.

The Green Sea Urchin, *Strongylocentrotus droebachiensis*, controls biomass, productivity, and diversity in shallow-water, benthic marine systems throughout much of its range (Foreman 1977; Hagen 1984; Himmelman 1985; Himmelman, Cardinal and Bourget 1983; Mann 1977). Understanding the mechanisms whereby urchin-dominated areas are generated and maintained will likely involve an understanding of the ecology of urchins at all life history stages.

The Green Sea Urchin has a major spawning period during the spring (Falk-Petersen and Lonning 1983; Himmelman 1978; Keats, Steele, and South 1984; Percy 1971). This spawning period was linked to the time of occurrence of a spring phytoplankton bloom by Himmelman (1978). There have also been suggestions from observations of changes in gonad indices that *S. droebachiensis* may also spawn in the summer or autumn (Himmelman 1969; Miller and

Mann 1973). Gonad content of urchins may vary considerably over a short distance (Himmelman 1978; Keats, Steele, and South 1984), and this makes the interpretation of slight changes in mean gonad indices unreliable as an indicator of spawning outside the main spring spawning period. The present paper reports direct observations of such spawning in the field.

Observations were made during 1983–1984. Diving was conducted weekly within a 0 to 10 m depth in urchin-dominated sites typical of the open Atlantic coast of Newfoundland (Table 1). Spawning was confirmed when gametes were seen oozing from the genital pores. The percentage spawning is based on subjective estimates of the proportion of the population observed to be spawning.

Table 1 presents a summary of the dates when and where summer spawning was observed in the field. The amount of spawning at each site was comparable

TABLE 1. Summary of observations of urchins spawning outside the spring period (all sites were sea urchin dominated, as is typical of most of the coast of eastern Newfoundland).

Date	Location	Estimated % spawning
31 March 1985	Fairhaven (47° 32'N, 53° 54'W)	<1%
17 June 1984	Bay Bulls (47° 19'N, 52° 46'W)	ca 10%, but v. patchy
11 July 1984	Gull Is. (47° 16'N, 52° 46'W)	<1%
16 September 1984	Trinity, Trinity Bay (48° 22'N, 53° 21'W)	ca 5%
28 September 1984	Bay Bulls	ca 10–15%

to that observed at the height of the spring spawning season (February–March).

These observations clearly indicate that a small portion of the sea urchins of eastern Newfoundland spawn outside the period during which a spawn-out of most of the individuals in the population occurs. The occurrence of spawning outside the normal spawning period is rare, but when observed may involve a comparable proportion of the local population. The contribution of these spawners to the total gamete production must be considered if accurate calculations of gamete production are to be made for wild urchin populations (Keats, Steele, and South 1984). These observations do not, however, alter the main conclusions reached by Keats, Steele, and South (1984).

While no direct evidence is available, it would seem most probable that these were instances of a delayed spawning caused by a lack of environmental stimulation. Such delays were produced experimentally by Himmelman (1975). A second spawning in the summer would be possible if adequate food was available to allow the gonads to reach full development by the summer. Keats, Steele, and South (1983), have shown that gonad development can be accelerated by providing supplementary food. However, urchins in eastern Newfoundland waters are often food-limited and may have difficulty in developing their gonads (Keats, Steele, and South 1984).

It is unlikely that summer spawning contributes any recruits to the population as suggested by Miller and Mann (1973), since embryonic development is disrupted at 10°C and above, according to Stephens (1972). Surface water temperatures off eastern Newfoundland are highly variable in early summer

but normally reach 10°C by late June (Steele 1974). Thus, any eggs spawned as late as June would be unlikely to hatch.

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Literature Cited

- Falk-Petersen, I., and S. Lonning. 1983. Reproductive cycles of two closely related sea urchin species, *Strongylocentrotus droebachiensis* (O. F. Muller) and *Strongylocentrotus pallidus* (G. O. Sars). *Sarsia* 68: 157–164.
- Foreman, R. E. 1977. Benthic community modification and recovery following intensive grazing by *Strongylocentrotus droebachiensis*. *Helgolander wissenschaftliche Meeresuntersuchungen* 30: 468–484.
- Hagen, N. T. 1983. Destructive grazing of kelp beds by sea urchins in Vestfjorden, northern Norway. *Sarsia* 68: 177–190.
- Himmelman, J. H. 1969. Some aspects of the ecology of *Strongylocentrotus droebachiensis* in eastern Newfoundland. M.Sc. thesis, Memorial University of Newfoundland, St. John's, Newfoundland. 159 pp.
- Himmelman, J. H. 1975. Phytoplankton as a stimulus for spawning in three marine invertebrates. *Journal of Experimental Marine Biology and Ecology* 20: 199–214.
- Himmelman, J. H. 1978. Reproductive cycle of the green sea urchin, *Strongylocentrotus droebachiensis*. *Canadian Journal of Zoology* 56: 337–348.
- Himmelman, J. H. 1985. Urchin feeding and macroalgal distribution in Newfoundland, eastern Canada. *Le Naturaliste canadien* 111: 337–348.
- Himmelman, J. H., A. Cardinal, and E. Bourget. 1983. Community development following removal of urchins, *Strongylocentrotus droebachiensis*, from the subtidal zone of the St. Lawrence Estuary, eastern Canada. *Oecologia* (Berlin) 59: 27–39.
- Keats, D. W., D. H. Steele, and G. R. South. 1983. Food relations and short term aquaculture potential of the green Sea Urchin (*Strongylocentrotus droebachiensis*) in Newfoundland. Memorial University of Newfoundland, Marine Sciences Research Laboratory Technical Report Number 24. 24 pp.
- Keats, D. W., D. H. Steele, and G. R. South. 1984. Depth-dependent reproductive output of the green sea urchin (*Strongylocentrotus droebachiensis* O. F. Mull.) in relation to the nature and availability of food. *Journal of Experimental Marine Biology and Ecology* 80: 77–91.
- Mann, K. H. 1977. Destruction of kelp beds by sea urchins: A cyclical phenomena or irreversible degradation. *Helgolander Meeresuntersuchungen* 30: 455–467.
- Miller, R. J., and K. H. Mann. 1973. Ecological energetics of the seaweed zone in a marine bay on the Atlantic coast of Nova Scotia. III. Energy transformed by sea urchins. *Marine Biology* 18: 99–114.

- Percy, J. A. 1971. Thermal acclimatization and acclimation in the echinoid, *Strongylocentrotus droebachiensis* (O. F. Muller, 1776). Ph.D. thesis, Memorial University of Newfoundland, St. John's, Newfoundland. 285 pp.
- Steele, D. H. 1974. Temperature and salinity cycles at the Marine Sciences Research Laboratory, Logy Bay, Newfoundland. Memorial University of Newfoundland, Marine Sciences Research Laboratory Technical Report Number 12. 21 pp.

- Stephens, R. E. 1972. Studies on the development of the sea urchin *Strongylocentrotus droebachiensis*. 1. Ecology and normal development. Biological Bulletin 142: 132-144.

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An Observation of Fighting Between Free-ranging Bobcats, *Lynx rufus*

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Jackson, DeWaine H., and Laura S. Jackson. 1987. An observation of fighting between free-ranging Bobcats, *Lynx rufus*. Canadian Field-Naturalist 101(3): 465-466.

A 26-minute confrontation between two free-ranging Bobcats (*Lynx rufus*) was observed on 10 April 1982. A description of the Bobcats' postures and behavior during the fight and possible explanations for the fight are given.

Key Words: Bobcat, *Lynx rufus*, behavior, Colorado.

Descriptions of intraspecific physical confrontations in wild Bobcats (*Lynx rufus*) are limited. This report describes a 26-minute fight between two free-ranging Bobcats on the Fort Carson Military Reservation, Colorado. On 10 April 1982, while we were locating a radio-collared adult female Bobcat she began approaching our location. We returned to our vehicle in the bottom of a canyon, and watched in the direction of the marked Bobcat. At 1540 h we observed with binoculars at approximately 90 m an unmarked adult-sized Bobcat running along the top edge of the canyon being chased by the marked Bobcat.

The unmarked Bobcat ran along the rim edge approximately 65 m, jumped down to a small ledge on the face of the 15 m high canyon wall, and backed into a small cavity near the ledge center. The marked Bobcat followed and a fight ensued, consisting of nape biting (Leyhausen 1979) and vocalizations (growling and hissing). At 1543 h the unmarked Bobcat lunged at the marked Bobcat, knocking it from the ledge; however, the marked Bobcat dangled from the ledge with the unmarked Bobcat grasping the radio-collar in its mouth. The marked Bobcat quickly returned to the ledge, freed herself and again forced the unmarked Bobcat into the cavity. With the unmarked Bobcat

bleeding lightly from the head and neck region, vigorous fighting continued until about 1550 h, followed by sporadic bouts involving only paw blows and scratching until 1600 h. During this fighting, the marked female appeared to be the attacker, while the unmarked Bobcat crouched defensively or fought while lying on its side and back.

At 1601 h both Bobcats fought vigorously and then simultaneously lay down, faced each other, and groomed their left front legs. At 1604 h the unmarked Bobcat arose, and slowly retreated along the ledge with the marked Bobcat following about 4 m behind. The marked Bobcat followed to the canyon rim and looked toward the location where we last observed the unmarked Bobcat. She appeared relaxed, based on body posture and ear position (Leyhausen 1979). She then lay down next to a large rock under a juniper (*Juniperus* sp.), groomed, and maintained a vigil toward the area where the unmarked Bobcat disappeared. At 1606 h the marked Bobcat stood up and slowly walked out of view into a brushy area. At 1630 h her radio signal came from where she was last observed, but it appeared to be moving west.

Both Bobcats exhibited similar postures and behaviors during the fight, nearly identical to

domestic cats (*Felis catus*) [Leyhausen 1979]. During most of the fight, ears were laid back, tails twitched continuously, vocalizations occurred during actual contact, and a front paw slap was the initial move in an aggressive encounter. The only obvious difference between our observation and Leyhausen's (1979) was that both Bobcats twice sat facing each other, vocalized, and used their right front paw to slap the head and shoulder of the opponent.

Territorial disputes may account for much of the aggressive behavior previously observed between Bobcats. Dispersing juveniles or transient adults that trespass are most likely to be involved with residents in territorial fights. Provost et al. (1973) observed an encounter where a juvenile male was treed by an adult male just after the juvenile had caught a rabbit (*Sylvilagus floridanus*). Litvaitis et al. (1982) reported that a juvenile Bobcat of unknown sex was killed and consumed by an adult female. Tracks in the snow indicated that a fight preceded the death. Hamilton (1982) observed two aggressive confrontations, one involving a marked juvenile male and a marked adult male that did not fight and the other involving a fight between a marked adult male and an unmarked Bobcat of unknown age and sex. Lembeck (1978) captured males and females with scars, tattered ears, and fresh cuts; injuries which were attributed to fighting with other Bobcats. Although Lembeck's report does not mention the age of the Bobcats, it substantiates that aggressive encounters occur in both sexes.

Mating behavior may account for a portion of the aggressive behaviors observed between Bobcats. Gashwiler et al. (1961) observed two adult females that may have been chewed around the neck during mating. McCord (1974) found up to 25 tufts of Bobcat hair at a single copulation site and suggested that Bobcats had cut the hair from each other during mating.

Mock battles and chases during mating were observed for Bobcats by McCord (1974) and described for domestic cats by Leyhausen (1979). Both reports indicate that females are chased by males, but neither described injury due to the chase or

mock battles. Mehrer (1975) indicates that although captive anestrus Bobcat females vehemently repel males, they would not pursue the males if the males jumped clear. Domestic male cats chase females during mating and chases occur only during territorial disputes or as part of mating behavior (Leyhausen 1979). If bobcat and domestic cat behavior is similar, the encounter we observed likely was the aggressive behavior displayed in a territorial dispute between free-ranging adult Bobcats.

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Literature Cited

- Gashwiler, J. S., W. L. Robinette, and O. W. Morris. 1961. Breeding habits of Bobcats in Utah. *Journal of Mammalogy* 42: 76-84.
- Hamilton, D. A. 1982. Ecology of the Bobcat in Missouri. M.Sc. thesis, University of Missouri, Columbia. 152 pp.
- Lembeck, M. 1978. Bobcat study, San Diego County, California. California Department of Fish and Game. Nongame Wildlife Investigations, Project E-W-2, Study 4, Job 1.7. 22 pp.
- Leyhausen, P. 1979. Cat behavior. Garland STPM Press, New York. 340 pp.
- Litvaitis, J. A., J. A. Sherburne, M. O'Donoghue, and D. May. 1982. Cannibalism by a free-ranging Bobcat, *Felis rufus*. *Canadian Field-Naturalist* 96: 476-477.
- Mehrer, C. F. 1975. Some aspects of reproduction in captive Mountain lions *Felis concolor*, Bobcats *Lynx rufus* and *Lynx Lynx canadensis*. Ph.D. thesis, University of North Dakota, Grand Forks. 137 pp.
- McCord, C. M. 1974. Courtship behavior in free-ranging Bobcats. *World's Cats* 2: 76-87.
- Provost, E. E., C. A. Nelson, and A. D. Marshall. 1973. Population dynamics and behavior in the Bobcat. *World's Cats* 1: 42-67.

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News and Comment

Admiralty Voyages and North American Ground Squirrels, *Spermophilus*

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Davis, David E. 1987. Admiralty voyages and North American ground squirrels, *Spermophilus*. Canadian Field-Naturalist 101(3): 467–468.

Four species of ground squirrels were named for British naval officers because of three dynamic decades of navy-sponsored exploration in northern North America in the early 1800s.

Key Words: *Spermophilus*, ground squirrels, arctic exploration.

A remarkable number of species of ground squirrels (genus *Spermophilus*) are named for British naval officers who explored the Arctic between 1818 and 1826. The ground squirrels (part of the tribe Marmotini) include perhaps 50 species in Siberia and North America. The species named for naval explorers are the following: (1) *Spermophilus parryi* (Richardson) ranges from Alaska to Hudson Bay; (2) *S. richardsonii* (Sabine) lives in the southern prairie provinces and northern prairie states; (3) *S. franklinii* (Sabine) inhabits prairies more to the east but overlaps *S. richardsonii* in many areas; (4) *S. beecheyi* (Richardson) ranges from northern Mexico to Washington.

After the Napoleonic wars the Royal Navy had an excess of ships, sailors, and admirals. The empire builders realized that an opportunity existed to find a northwest passage and to obtain valuable scientific information, especially nautical. Two far-sighted men developed a program. John Barrow, Permanent Secretary of the Admiralty, and Edward Sabine, President of the Royal Society, promoted exploration for three decades. The plan was to send one expedition west of Greenland to search for a passage, two overland to explore the McKenzie and Coppermine rivers, and a fourth to come east from the Bering Strait. Needless to say, the travels were arduous and dangerous; Franklin died in northern Canada. By 1826 the project showed that, while a passage existed, the extensive fields of ice prevented its use.

All of the expeditions had naturalists who were usually astronomers and surgeons. They were instructed to collect data and specimens at every opportunity. The plants and animals were given to the Royal Society and described in subsequent years.

The four leaders had somewhat different lives. Sir William Edward Parry, born in Bath in 1790, served throughout the Napoleonic wars. He made several voyages to the Canadian Arctic, first under Sir John Ross and later with his own command. In his later years he held a variety of positions in the Admiralty. Sir John Richardson, born in Scotland in 1787, obtained an M.D. and served as Surgeon in the Napoleonic wars. He accompanied Sir John Franklin in 1819–1822, and in 1825–26 he led an expedition along the arctic shore from the Mackenzie to the Coppermine. He commanded the search expedition for Franklin in 1848.

Sir John Franklin, born in England in 1786, entered the Royal Navy in 1800 and fought at the Battle of Trafalgar. In 1819 he commanded an expedition to the mouth of the Coppermine and nearly starved. In 1825–27 he explored the arctic coast. In 1845 he made a third expedition. His ships were frozen in the ice and all persons starved. Frederick William Beechey (1796–1856) served in the Royal Navy in Africa, North America and South America. He served under both Parry and Franklin in their arctic expeditions. In 1825 he sailed around Cape Horn, along the western coast of North America and through the Bering Strait in a vain attempt to find the northwest passage. After 1828 he remained on shore in poor health.

Two other ground squirrels were named for explorers. *S. townsendii* (Bachman) was collected in Oregon by Townsend who was sent west by the Academy of Natural Sciences of Philadelphia. *S. douglasi* (Richardson) [now considered a subspecies of *S. beecheyi*] was collected by David Douglas on a trip to Canada and the northern United States

sponsored by the London Horticultural Society. The animals were given to Richardson for description by Joseph Sabine, secretary of the Royal Society, a prominent ornithologist and brother of Edward Sabine.

At least 14 other forms of ground squirrels were named for people but none of them were associated with arctic explorations. One subspecies, *S. parryi barrowensis* (Merriam), now *S. p. kennecottii* (Ross), was named for the place, Pt. Barrow, which had been named for Admiral John Barrow. Several Siberian species are named for Russian explorers but these persons were not part of the British Admiralty's project to search for the Northwest Passage.

These comments will serve to call attention to a splendid episode in the history of Canadian mammals. The following references provide ample details for those who wish to learn more about the exciting adventures in the search for the Northwest Passage. (Recent books or reprints are listed for availability, but read the originals if possible!).

Literature Summary

Davies, John. 1980. Douglas of the forests. University of Washington Press, Seattle, Washington. 188 pages.

Fisher, Alexander. 1821. A journal of a voyage of discovery to the arctic regions in his majesty's ships Hecla and Gripper in the years 1819 & 1820. Longmans, London. 320 pages.

Gough, Barry M. 1973. To the Pacific and Arctic with Beechey. Journal of Lieutenant George Peard of HMS' *Blossom* 1825-1828. Cambridge University Press, Cambridge, England. 272 pages.

Nauton, P. 1970. Arctic breakthrough: Franklin's expeditions. Toronto. 262 pages.

Parry, Ann. 1963. Parry of the Arctic. Chatto and Windus, London. 240 pages.

Richardson, Sir John. 1829. The quadrupeds. Fauna Boreali America 1: 147-180.

Sabine, Joseph. 1822. Account of the marmots of North America hitherto known with notes and description of three new species. Transactions of the Linnean Society (London) 13: 579-591.

Townsend, John Kirk. 1970. Narrative of a journey across the Rocky Mountains, to the Columbia River. Ye Galloway Press. Pages 165-379.

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Avian Family-Group Names

The Standing Committee on Ornithological Nomenclature of the International Ornithological Committee has prepared a list of established names of avian family-group taxa (subtribes to superfamilies) and their synonyms as the first step in the process of writing an application to the International Commission on Zoological Nomenclature to stabilize use of these names. The SCON wishes to obtain input from all interested ornithologists and zoologists on this list of avian family-group names and its proposed application to the ICZN. The list is available to all

interested ornithologists and zoologists who are willing to examine it carefully and provide the SCON with corrections, additions, comments, and suggestions. This list of avian family-group names is unofficial and should not be used for any purposes other than that just mentioned. Copies of the list may be obtained by writing to:

WALTER J. BOCK

Chairperson, SCON, Department of Biological Sciences, Columbia University, New York, New York 10026

Ornithology Checklist for Canada

The Canadian Society of Ornithologists has arranged for the publication of a *Checklist of Canadian Birds/Liste de référence des oiseaux du Canada*. This list, prepared by Dr. R. D. James of the Royal Ontario Museum, gives the scientific, French and English common names and breeding status of all 579 species of bird recorded in Canada up to the end of 1984. It corresponds to the birds described by Earl Godfrey in his second edition (1986) of *The Birds of Canada*.

The list is bound in pocket-size form and would be a useful addition to any naturalists field gear.

Copies can be obtained by sending two dollars (\$2.00) to Ornithology Checklist c/o the undersigned.

W. BRUCE MCGILLIVRAY

Treasurer, Canadian Society of Ornithologists

Provincial Museum of Alberta, 12845-102 Avenue, Edmonton, Alberta T5N 0M6

Up-date: Status of the Southern Maidenhair Fern, *Adiantum capillus-veneris* (Adiantaceae), in Canada

In my recent report on the status of this endangered species in British Columbia and Canada (D. F. Brunton, 1986. Status of the Southern Maidenhair Fern, *Adiantum capillus-veneris* (Adiantaceae), in Canada. Canadian Field-Naturalist 100(3): 404-408), I questioned the likelihood of its continued survival at the only Canadian station. The increasing degradation of the microclimatic conditions at the site is seriously threatening the entire, tiny population. Recently, however, Gerald B. Straley, Curator of Collections at the Botanical Garden, University of British Columbia, Vancouver, advised me that plants from the site have been in culture at that institution for a number of years. Plants were taken at a time when the species was much more abundant at the Fairmont Hot Springs site. This collection of living material ensures that a supply of living material (which Straley reports to be producing spores) is available if a re-introduction program is required in the future.

I was also recently advised by R. H. Kerbes, Wildlife Biologist with the Canadian Wildlife Service in Saskatoon, Saskatchewan, that he and Eveline Boudreau observed the fern at the site in 1987. Further, Kerbes had been in contact with a member of the senior management of the Fairmont Hot Springs Resort who is enthusiastic about implementing protective management for the species' habitat. The future for the Southern Maidenhair Fern in Canada is looking significantly brighter, thanks to the interest and actions of these individuals.

I would be pleased to hear of any other information on this species in Canada that readers may be aware of. My thanks to Gerald Straley and Richard Kerbes for their important and encouraging communications.

DANIEL F. BRUNTON

2704 Marie Street
Ottawa, Ontario K2B 7E4
Received 10 July 1987

The George P. Holland Memorial Fund

Most of you know the tragic news that George P. Holland, 14 Kitimat Crescent, Nepean, Ontario K2H 7G5, died on 10 November 1985 from exposure during a hunting trip to his favorite lodge near Ottawa. George retired in 1976 and since then had devoted much of his time to finishing his monograph on the fleas of Canada, Alaska, and Greenland (published in early 1985).

George was known world-wide for his many contributions to the taxonomy of fleas. He began his career in entomology at the Canada Department of Agriculture laboratory at Kamloops, British Columbia, and then moved to Ottawa to serve as head of the old Systematic Entomology Unit and then as director of the Entomology (now Biosystematics) Research Institute.

Under George's leadership, the Canadian National Collection (CNC) of insects and related arthropods grew to be one of the best collections of its kind in the world with extensive nearctic holdings, especially from the arctic region, and with good collections from other areas of the world, such as New Guinea, Mexico, Jamaica, Europe, etc. During his tenure as director, the CNC grew from a relatively small collection of about 1 000 000 specimens to one with about 10 000 000 specimens.

The George P. Holland Memorial Fund has been established by the CanaColl Foundation in his memory. The fund is ongoing and can be added to at any time. CanaColl is an independent organization devoted to promoting research and development of the CNC. The accrued interest from this memorial fund will be used to support curation on the CNC.

Donations in memory of George may be sent to the CanaColl Foundation (address below); receipts for income tax purposes will be sent for all donations of \$5.00 or more. The Holland family will be informed of the names of those who have made donations to the fund.

Please share this notice with anyone else who might be interested. If you want more information, please don't hesitate to ask.

May this and other sentiments from friends be a source of comfort to the Holland family at this time.

THE CANACOLL FOUNDATION

K.W. Neatby Building, Room 4058,
1010 Carling Avenue,
Ottawa, Ontario K1A 0C6

A Tribute to GEORGE PEARSON HOLLAND, 1911–1985

GRANT M. CARMAN

29 Evergreen Drive, Nepean, Ontario K2H 6C5

George was born in Vancouver, British Columbia, within sight of the mountains that he loved and that early served as a classroom for him in his career of biology. In the chosen field of entomology he rapidly worked his way up, culminating in his appointment as director of the Entomology Research Institute in Ottawa in 1959.

His life was one of scholarship, and his hobbies were numerous. His antique gun and weapons collection has few rivals, and his camera and glasses went with him as constant companions so he could identify every bird and every animal in the outdoors that he loved so much. When he named a bird or animal, it was always by its correct taxonomic name first and its common name later. His slide and photo collection is likely the dream of many amateur ornithologists and anthropologists.

George was first and foremost a family man. He was intensely proud of his wife and his three children — Judy, George and Penny — and his very way of speaking of them told you of his affection for them and for their grandchildren whose picture he would show you instantly. Life with George was certainly never dull for Jenny and the kids, as it never was for those friends that he contacted on his way through life.

And it is of the man who was our friend that I wish to speak this morning: The man whose love for life brightened each day and each person that he met; the man that was not only a director to his staff, but a father-confessor and a strong shoulder when the need arose; the man who loved a practical joke and a good story, and whose zest for life never diminished, no matter how hard were the physical and mental disabilities that were to plague him later in life. Despite the handicaps, he completed his monograph that will continue as a guide for fellow scientists for decades to come. But I ask you to look back on your life around George Holland and recall those episodes that make you smile in memory while I tell you of a few that linger with me.

George used to have the office above me, and at lunchtime I would often hear a thump on the steam pipe — this was an invitation to dinner. Politics, science, fishing, guns — the variety of topics never ended — and my education by this erudite man never ended. One day a T.V. team came in to take a picture of George and the Institute, and it ended back in his

office looking at a pet tarantula. Only George amongst us realized that the reporter did not know that it was alive, and suddenly when George was gently stroking it, it waved its legs. The T.V. camera was instantly empty of one reporter, and the voice of the interviewer was distant and faint as he spoke from the doorway for the rest of the program. George and I celebrated over a glass of scotch as we ate our lunch!

Once, after a trip to Hawaii both George and I brought back slides, and I showed mine to various horticultural groups around the area, and loaned them to George to view them at home. He and Eugene Monroe had just come back from a trip to Papua and New Guinea, and thereby hangs the tale. I showed my slides the next evening to the Women's Teachers Federation at Manotick. As a final picture I always showed three gorgeous hula dancers, but when I flooded the slide on the screen I had one beautiful Papuan girl clad only in an hibiscus in her hair! George had suckered me, but good! When I went looking for him the next day my anger evaporated as I stood outside his office door and overheard him regaling Gene Monroe of the picture switch and the results!

Another George Holland was the man I took into the Byng Club for the first time, and loaned a buck-tail to fish for lake trout. When I came in at noon George met me with a grin that rivalled the sun, and an 11 pound trout! He loved that club as his second home ever since that day and I never did regain the buck-tail!

And when the fishing was over that evening, and supper was done, George took out his beloved accordion and we sang every song we ever knew, and he played us melodies that we had never heard before or since. And then in the silence of the twilight he sat and recited poetry for us that we had long since forgotten — but he had not. This was the George Holland that loved to give, and gave with all his heart and mind.

And in the hunting camp there is a favorite watch that we call the "Fallen Balsam." In the stump lies a green Mateus bottle that George carried there one chilly day, for he was never one to completely forget his creature comforts. And everytime we referred to the "Fallen Balsam" a voice would gently interrupt and say "Eastern White Pine." This is the story of a man who lived the way he loved to among the rest of us hunters at the Beavertrail.



George Holland

This is the man that we gather here today to remember. This is the man that gave us so much and so many memories.

This is the man for whom you can truly say "he was a gentleman and a scholar" in every sense of the word.

The world is a better place because he passed this way!

12 November 1985

Publications of G. P. Holland

Compiled by Edward C. BECKER

Biosystematics Research Centre, Agriculture Canada, Ottawa, Ontario K1A 0C6

Research (44)

Holland, G. P. 1939. Phenomenal infestation of ectoparasites on marmot, weasel and packrat. Proceedings of the Entomological Society of British Columbia 35: 27-28, 1 figure.

Mail, G. A., and G. P. Holland. 1939. Siphonaptera of western Canada in relation to sylvatic plague. Proceedings of the Sixth Pacific Science Congress 5: 125-128.

Holland, G. P. 1940. Notes on the ecology of *Dermacentor andersoni* in Southern Alberta. Proceedings of the Entomological Society of British Columbia 36: 8-11.

Holland, G. P. 1940. New records of Siphonaptera for British Columbia. Proceedings of the Entomological Society of British Columbia 36: 11-12.

Stewart, M. A., and G. P. Holland. 1940. A new genus of the family Dolichopsyllidae (Siphonaptera) from Canada. Canadian Entomologist 72: 41-42; 2 figures.

Holland, G. P. 1941. A survey of the rat fleas of British Columbia with relation to plague studies. Proceedings of the Entomological Society of British Columbia 37: 1-5.

Holland, G. P. 1941. Further records of Siphonaptera for British Columbia. Proceedings of the Entomological Society of British Columbia 37: 10-14.

Holland, G. P. 1942. On the occurrence of *Reithrodontomys* in British Columbia. Murrelet 23: 60.

Holland, G. P. 1942. Synonymy of some fleas from Western North America (Siphonaptera). Canadian Entomologist 74: 157-158.

Holland, G. P. 1943. A remarkable instance of retention of a double spermatheca in a dolichopsyllid flea, *Opisocrostis bruneri* (Baker). Canadian Entomologist 75: 175-176; 1 figure.

Holland, G. P. 1944. The distribution of some plague-important rodents and fleas in western Canada. Proceedings of the Entomological Society of British Columbia 41: 5-12; 1 figure.

Editor's Note: This special tribute to a friend was presented at the service for George Holland in Ottawa by Grant Carman and later written out for publication at our request.

Other published tributes are:

Munroe, E. G. 1986. George Pearson Holland 1911-1985. Transactions of the Royal Society of Canada, Series V, Volume 1, pp. 303-305.

Downes, Antony, and Robert Glen. 1986. George Pearson Holland 1911-1985. Entomological Society of Canada Bulletin 18(2): 71-75.

Gregson, J. D., and G. P. Holland. 1944. Devices for charting and obtaining naturally emerged cattle warbles (Diptera: Oestridae). Proceedings of the Entomological Society of British Columbia 41: 31-33; 2 figures.

Holland, G. P. 1944. Notes on some northern Canadian Siphonaptera, with the description of a new species. Canadian Entomologist 76: 242-246; 10 figures.

Holland, G. P. 1949. A revised check list of the fleas of British Columbia. Proceedings of the Entomological Society of British Columbia 45: 7-14.

Holland, G. P., and E. W. Jameson, Jr. 1949. Notes on some Nearctopsyllinae, with descriptions of two new species of *Nearctopsylla* from California (Siphonaptera). Canadian Entomologist 81: 249-253; 6 figures.

Holland, G. P. 1949. The Siphonaptera of Canada. Canada Department of Agriculture Technical Bulletin 70 306 pp.; 350 figures.; 44 maps.

Holland, G. P. 1950. Notes on some British Columbian fleas, with remarks on their relationships and distribution. Proceedings of the Entomological Society of British Columbia 46: 1-9.

Holland, G. P. 1950. Notes on *Megabothris asio* (Baker) and *M. calcarifer* (Wagner) with the description of a new subspecies (Siphonaptera: Ceratophyllidae). Canadian Entomologist 82: 126-133; 8 figures.

Holland, G. P. 1951. A note on the occurrence of *Catallagia dacenkoi* Ioff in North America, with the description of a nearctic subspecies (Siphonaptera: Neopsyllidae). Canadian Entomologist 83: 156-160; 7 figures.

Holland, G. P. 1951. Notes on some bird fleas, with the description of a new species of *Ceratophyllus* and a key to the bird fleas known from Canada (Siphonaptera: Ceratophyllidae). Canadian Entomologist 83: 281-289; 10 figures.

Holland, G. P. 1952. Notes on some Siphonaptera from Canada. Canadian Entomologist 84: 65-73; 3 figures.

- Holland, G. P.** 1952. Description of fleas from northern Canada (Siphonaptera). *Canadian Entomologist* 84: 297-308; 25 figures.
- Holland, G. P., and W. L. Jellison.** 1952. On *Mioctenopsylla* Rothschild, a genus of Siphonaptera (Ceratophyllidae) with description of a new species. *Canadian Entomologist* 84: 374-379; 10 figures.
- Holland, G. P.** 1954. The crow flea, *Ceratophyllus rossittensis* Dampf, in North America (Siphonaptera: Ceratophyllidae). *Canadian Entomologist* 86: 334-336; 7 figures.
- Holland, G. P.** 1954. A new species of *Catallagia* Rothschild from the Rocky Mountains of Alberta (Siphonaptera: Hystrichopsyllidae: Neopsyllinae). *Canadian Entomologist* 86: 381-384; 7 figures.
- Holland, G. P.** 1955. Siphonaptera. Pp. 585-588 in *A Century of Progress in the Natural Sciences*. California Academy of Science.
- Holland, G. P.** 1955. Primary and secondary sexual characteristics of some Ceratophyllinae, with notes on the mechanism of copulation (Siphonaptera). *Transactions of the Royal Entomological Society of London* 107: 233-248; 13 figures.
- Holland, G. P.** 1957. Notes on the genus *Hystrichopsylla* Rothschild in the New World, with descriptions of one new species and two new subspecies (Siphonaptera: Hystrichopsyllidae). *Canadian Entomologist* 89: 309-324; 29 figures.
- Holland, G. P., and G. Loshbaugh, Jr.** 1958. Two new species of fleas from Utah, with notes on the genus *Ornithophaga* Mikulin (Siphonaptera). *Canadian Entomologist* 90: 486-493; 12 figures.
- Holland, G. P.** 1958. Distribution patterns of northern fleas (Siphonaptera). *Proceedings of the Tenth International Congress of Entomology* 1: 645-658; 6 maps.
- Holland, G. P.** 1959. An unusual case of teratology in Siphonaptera. *Canadian Entomologist* 91: 703-709.
- Holland, G. P.** 1960. A new species of *Catallagia* Rothschild from Arizona (Siphonaptera: Hystrichopsyllidae: Neopsyllinae). *Canadian Entomologist* 92: 767-770.
- Holland, G. P.** 1960. Descriptions of two new species of *Ceratophyllus* Curtis from Yukon Territory (Siphonaptera: Ceratophyllidae). *Canadian Entomologist* 92: 787-793.
- Holland, G. P.** 1963. Faunal affinities of the fleas (Siphonaptera) of Alaska: with an annotated list of species. Pp. 45-63 in *Proceedings of the Tenth Pacific Science Congress*.
- Holland, G. P.** 1964. Evolution, classification and host relationships of Siphonaptera. *Annual Review of Entomology*: 123-146.
- Holland, G. P.** 1965. New species and subspecies of *Anomiopsyllus* Baker from Mexico (Siphonaptera: Hystrichopsyllidae). *Canadian Entomologist* 97: 1051-1058.
- Holland, G. P., and A. H. Benton.** 1968. Siphonaptera from Pennsylvania mammals. *American Midland Naturalist* 80: 252-261.
- Holland, G. P.** 1969. Contribution towards a monograph of the fleas of New Guinea. *Memoir of the Entomological Society of Canada*, Number 61. Pp. 1-149.
- Holland, G. P.** 1971. New Siphonaptera from southern Mexico. *Canadian Entomologist* 103: 95-104.
- Holland, G. P.** 1971. A new genus and species of flea from Tasmania (Siphonaptera: Pygiopsyllidae). *Canadian Entomologist* 103: 125-129.
- Holland, G. P.** 1971. Two new species and three new subspecies of *Acanthopsylla* from Australia, with some notes on the genus (Siphonaptera: Pygiophyllidae). *Canadian Entomologist* 103: 213-234.
- Holland, G. P.** 1971. Notes on the genus *Pygiopsylla* Rothschild, Group B, in Australia with the description of three new species (Siphonaptera: Pygiopsyllidae). *Journal of the Australian Entomological Society* 10: 65-82.
- Holland, G. P.** 1979. Three new species of fleas from Canada (Siphonaptera). *Canadian Entomologist* 111: 713-719.
- Holland, G. P.** 1985. The fleas of Canada, Alaska and Greenland (Siphonaptera). *Memoir of the Entomological Society of Canada*, Number 130. 631 pp.

Miscellaneous (14)

- Holland, G. P.** 1951. Insects in Canadian amber. *Division of Entomology Newsletter* 29(12): 1-20.
- Holland, G. P.** 1953. Systematic Entomology Unit, 1919-1953. *Division of Entomology Newsletter* 31(5): 2-3.
- Holland, G. P.** 1954. Systematic Entomology. Pp. 189-190 in *Canada: a review of economic entomology: 1946-1954*. Compiled by R. Glen. Report, Sixth Commonwealth Entomology Conference, London.
- Holland, G. P.** 1956. Systematic Entomology. In *Entomology in Canada up to 1956: a review of developments and accomplishments*. Compiled by R. Glen. *Canadian Entomologist* 88: 300-304.
- Holland, G. P.** 1958. Frustrations of a flea hunter in New Guinea. *Entomology Division Newsletter* 36(10): 1-2.
- Holland, G. P.** 1959. Karl Jordan, 1861-1959. *Entomology Division Newsletter* 37(2): 3.
- Holland, G. P.** 1960. The Canadian National Collection of Insects. *Professional Public Service* 39: 6-10.
- Holland, G. P.** 1962. Save those fleas? *Australian Mammal Society Bulletin* 5: 6-9.
- Holland, G. P.** 1965. The role of insect collections in entomological research. *Annals of the Entomological Society of Quebec* 10: 109-119.
- Holland, G. P.** 1965. L'Abbé Léon Provancher, 1820-1892. Pp. 44-53 in *Pioneers of Canadian Science*, a symposium presented to the Royal Society of Canada in 1964. University of Toronto Press.
- Holland, G. P.** 1965. Entomology in Canada (address for the opening at the Royal Ontario Museum of the special exhibit marking the Centennial of Entomology in Canada, 1963). *Royal Ontario Museum, Life Sciences Contribution Number* 69: 7-13.
- Holland, G. P.** 1974. Biography of Robert Glen. *Bulletin of the Entomological Society of Canada* 6(1): 3-6.
- Holland, G. P.** 1979. Siphonaptera. Pp. 424-426 in *Canada and its insect fauna*. Edited by H. V. Danks. *Memoir of the Entomological Society of Canada*, Number 108.
- Holland, G. P.** 1979. Gold Medal Address. *Bulletin of the Entomological Society of Canada* 11: 79-82.

[List does *not* include a number of book reviews.]

Thesis

- Holland, George Pearson. 1937. Life history and distribution studies of Bell's Painted Terrapin, *Chrysemis picta bellii* (Gray). M.A. thesis, University of British Columbia, Vancouver. 144 pp., 46 figures.

An Inventory of Ecologically Significant Natural Vegetation in the Province of Ontario: I. Essex County

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Maycock, Paul F., and Dianne Fahselt. 1987. An inventory of ecologically significant natural vegetation in the province of Ontario: I. Essex County. *Canadian Field-Naturalist* 101(3): 474-486.

A comprehensive list of ecologically important sites in Essex County, Ontario includes 45 areas, a number of which are small and homogeneous and others complex with varied environments each supporting a different plant community. All are significant because less than 2% of the natural vegetation remains in this region. Each site is provided with a succinct edaphic/moisture description and is identified by listing the major dominant plant species. Many of the sites documented in this list are supported by detailed quantitative data collected by P. F. M. which serve as a baseline against which changes or losses can be gauged.

Key Words: Preservation, conservation, natural areas, ecologically significant vegetation, Essex County, Ontario.

The natural heritage of Canada embodied in rivers, lakes, mountains and vegetational landscapes is in many regions under serious threat but nowhere more so than in southwestern Ontario. The initial clearance of vegetation for agriculture was inevitable as is continued exploitation for raw materials. Unlimited destruction, however, to the point where no representative examples remain even for scientific research, education, nature appreciation and aesthetic enjoyment, is unreasonable.

Recognizing the serious rate of decline of natural vegetation in Canada, the Conservation Committee of the Canadian Botanical Association recommended that lists of vegetation communities be compiled for all regions of the country in order to document remaining ecologically significant sites. Although *floristic lists*, that is lists of the different species of plants which grow in a region, have been initiated previously, there are no *vegetational lists* of the compositional, structural and ecological expression of these floristic elements in communities for Canada, for any of its provinces and probably none even for individual counties.

Vegetational systems which are highly unusual in Ontario and Canada occur in the Carolinian region of southern Ontario. Tallgrass prairie inclusions and the luxurious summergreen deciduous forests are examples of the many unusual communities. It is precisely in the Carolinian region, however, that destruction of natural ecosystems is most rampant and land-use conflicts are most serious. Many townships in Essex, Kent and Elgin counties have lost more than 99% of their original natural vegetation cover. Compilation of important sites in Ontario, therefore, has been initiated within this region. This

list deals with Essex County, the most southwestern Ontario county, which is in the Southern Deciduous Forest region (Maycock 1963) and the Lake Erie Site Region (Hills 1959, 1961).

Potential Uses and Problems

Natural vegetational communities constitute the only source of new plants for economic exploitation, valuable sources for undiscovered drug and medicinal plants, and repositories of plant variation with supporting gene pools. Natural vegetation forms the protective photosynthesizing mantle of the earth. The ultimate purpose of documenting areas which are important from a vegetational standpoint is to raise awareness of these areas in the hope that it will facilitate their protection.

Ecologists are frequently called upon to defend sites harbouring important natural features and it is critical to be able to document the importance of a particular site at public inquiries. If the sites have not previously been studied in detail or results of studies not reported it is often difficult for lay supporters or even scientists to formulate convincing supportive arguments. When a botanist contends that a specific area is significant and deserves protection, his views tend to be taken as personal opinion with no generally accepted basis in fact. The point is often made that if a site had received no recognition prior to the controversy it must not be particularly significant. The inclusion of an area in a refereed and widely distributed national scientific publication should serve as a reliable indication of importance.

Landowner awareness of the values of property are frequently heightened if the holdings are included in a

register of critical sites (Hilts and Moull 1985*). In both privately and publicly owned sites, even if they are not the object of any particular litigation, degradation often occurs simply due to inappropriate management. Once landowners have been given the opportunity to appreciate the significance of properties in the provincial or national context they may be encouraged to use lands wisely. There may even be a desire to enter into a protection agreement which would officially acknowledge the natural values of such holdings.

A register of important sites is of practical importance to land use planners, who frequently attempt to discover locations of areas which support environmentally sensitive plant communities. While some sites have been the object of observation and study by competent scientists or naturalists, the results of these efforts are frequently unpublished and unavailable. In lieu of formally published detail concerning each site, a list of vegetationally important areas and a reference indicating where more information is available should be helpful. Other advantages of compiling an extensive list are that it would permit the rate at which sites are lost to be monitored and, in those cases where quantitative information is available, would allow a comprehensive picture to be developed of the range of plant communities occurring under natural or semi-natural conditions. It would also provide documentation of compositional differences at a site through time.

It could be argued that publicizing a list of important sites might hamper efforts to preserve them because land prices could escalate and make purchase impossible. However, many areas are needed to adequately represent all types of natural plant communities and the possibilities are remote that all sites needing protection could ever be purchased. Therefore, a property owner would usually find it unproductive to inflate the price asked. Escalation of prices would also be discouraged if owners realized that a considerable number of properties other than their own were also listed as significant.

Another possible problem is that any important area which was inadvertently omitted might appear less crucial than it perhaps should. However, publishing no list at all is an even less desirable alternative.

Previous Analysis

Considerable Forest Resource Inventory (FRI) data for Essex County already have been indexed and mapped and are available from the Ministry of

Natural Resources (see Source Documents). These data, however, relate primarily to merchantable overstorey species in terrestrial sites and their quality is variable. A recent compilation by Oldham (1983*) has made a significant contribution to the identification of important areas in Essex County. Botanical significance in terms of rare or unusual species was his major basis for including sites, rather than quantitative or community criteria. Earlier studies sponsored by the Ontario Ministry of Natural Resources in Essex County resulted in other in-house publications, each with a botanical component: East Sister Island and Pelee Island (Campbell 1971*; 1976*), Tremblay Beach (Macdonald and Beechey 1970*), Ojibway Prairie (Pratt 1979*), the Holiday Beach area (Klinkenberg 1982*) and Site Region 7-1 (Klinkenberg 1985*). All but the Ojibway study emphasized a descriptive floristic approach to vegetation study.

A community approach has also been adopted in studying many areas in Essex County. Vegetation has been intensively analyzed using quantitative ecological methods or has been studied using extensive non-quantitative methods. However, for the most part there has been no way for an interested party to learn of the study sites except through the personal data files of the investigators. For Essex County, for the rest of Ontario and much of forested Quebec, most of the quantitative vegetational data have been collected by personnel from the Plant Ecology Laboratory at Erindale College (PFM and associates) where detailed site descriptions and vegetational data for these areas are on file.

Data Base

All stands of vegetation included in Table 1 are homogeneous with respect to major plant dominants and are judged to be viable and self-perpetuating. They have been listed in order of approximate geographic proximity; their locations are shown in Figure 1.

Generally they conform to certain minimum size standards of three to five acres for forests and one acre for other communities. The primary sources of data are the 1970* data of the International Biological Program (IBP sites), the Ontario Ministry of Natural Resources land-use strategies, and the site/vegetational studies in the data files of PFM. Those of other ecological workers and naturalists are included if satisfactorily documented in terms of major dominants and associates. All entries are accompanied by source citations so that additional details of exact location, specific vegetational and landform data and other environmental information for individual sites may, when justified, be obtained. Sites

*source document, see section listing these.

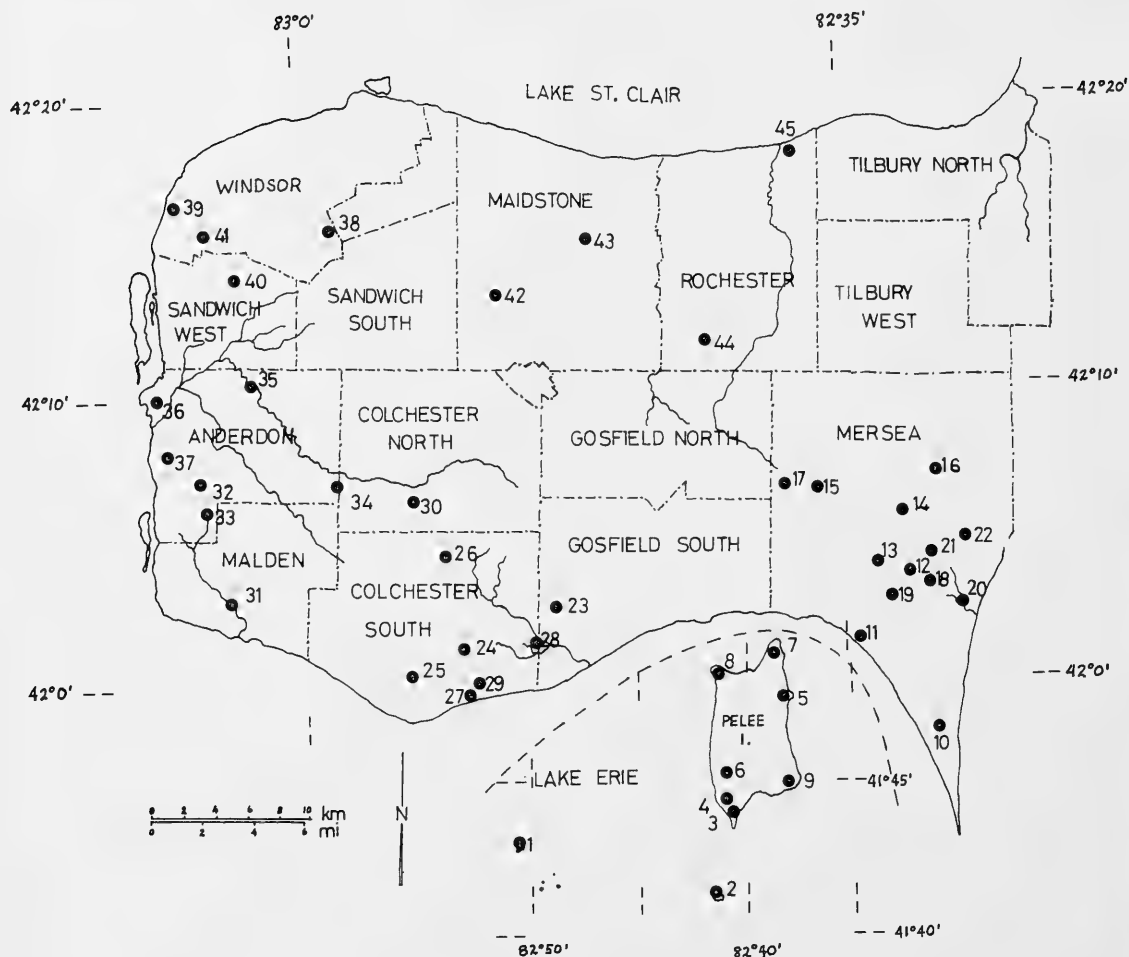


FIGURE 1. Location of known sites of ecologically significant vegetation in Essex County. 1. East Sister Island. 2. Middle Island. 3. Fish Point. 4. McCormick's Woods. 5. Middle Point. 6. Red Cedar Savanna. 7. Lighthouse Point. 8. Sheridan Point. 9. Stone Road Prairie Alvar. 10. Point Pelee National Park. 11. Sturgeon Creek. 12. Leamington Sand Hills. 13. Leamington Beechwoods. 14. Leamington White Oak Wood. 15. Wigle. 16. Mount Carmel. 17. Cameron Scott's Woods. 18. Wheatley Sand Hills. 19. Hillman Oak-Tulip. 20. Hillman Marsh. 21. Hillman Sand Hills. 22. Kopegaron Wood. 23. Arner Lowland Forest. 24. Arner Spleenwort Woods. 25. Colchester Sand Plain. 26. Marshfield Clay Plain. 27. Harrow. 28. Cedar Creek. 29. Oxley. 30. Barretville Clay Plain. 31. Big Creek Marsh. 32. Upper Big Creek. 33. Amherstberg. 34. Canard River Bottoms. 35. Canard River Scout Camp. 36. Canard River Mouth Marsh. 37. Splitlog. 38. Devonwood. 39. Ojibway West. 40. Sandwich West. 41. Ojibway Prairie. 42. Fair Play. 43. Emeryville Clay Plain. 44. Ruscomb. 45. Ruscomb Shores.

described only in Forestry Resource Inventory data have not been included because their significance is not clear without on-site inspection to determine environmental parameters, correct plant identifications and the contribution of non-commercial species.

Each site is provided with a name (usually the nearest locality on the national topographic series

map), site moisture and major soil features, and a description of the vegetational characteristics. A listing of the dominant species (nomenclature according to Fernald 1950) is usually presented in decreasing order of quantitative significance although the basis for this may vary depending on the source. In the Maycock studies, the criterion is decreasing order

TABLE 1. Significant vegetation of Essex County, Ontario. Vegetation descriptions include: site moisture and general vegetation type — substrate — dominants of the community. The reference following each description refers to the data source. Major dominant species when known precede the oblique stroke. Vegetation in bold type is known to have been already lost. References in parenthesis are presented in this form: ecologist's name – stand number – year; or author – source – year. MNR = Ministry of Natural Resources, LSI = Life Sciences Inventory, IBP = International Biological Program, ER = Environmentally Significant Areas of the Essex Region (Oldham 1983), obs = Observation only, no quantitative or descriptive data.

Location	Vegetation
1. East Sister Island, Pelee Township (41°43'N, 82°50'W)	Dry-mesic upland deciduous forest — limestone bedrock — <i>Celtis occidentalis</i> – <i>Acer nigrum</i> / <i>Tilia americana</i> – <i>Quercus muhlenbergii</i> – <i>Carya ovata</i> – <i>Fraxinus americana</i> – <i>Gymnocladus dioica</i> (Lindsay MNR-LSI-1979; Macdonald-IBP-1971). Wet-mesic lowland deciduous forest — limestone bedrock — <i>Fraxinus pennsylvanica</i> – <i>Ulmus americana</i> – <i>Celtis occidentalis</i> / <i>Populus deltoides</i> – <i>Gymnocladus dioica</i> – <i>Tilia americana</i> (Lindsay-MNR-LSI-1979; Macdonald-IBP-1971). Wet lowland deciduous forest — muck — <i>Acer saccharinum</i> – <i>Ulmus americana</i> – <i>Fraxinus pennsylvanica</i> – <i>Prunus virginiana</i> (Lindsay-MNR-LSI-1979; Macdonald-IBP-1971). Dry mesic tall shrub thicket — limestone bedrock — <i>Prunus virginiana</i> – <i>Rhus radicans</i> / <i>Cornus drummondii</i> – <i>Sambucus canadensis</i> – <i>Euonymus atropurpureus</i> (Lindsay-MNR-LSI-1979; Macdonald-IBP-1971).
2. Middle Island, Pelee Township (41°41'N, 82°42'W)	Dry upland deciduous forest — sand — <i>Celtis occidentalis</i> – <i>Fraxinus quadrangulata</i> – <i>Quercus muhlenbergii</i> – <i>Morus rubra</i> – <i>Gymnocladus dioica</i> – <i>Gleditsia triacanthos</i> (Oldham-ER-1983). Very dry upland tall thicket — sand — <i>Ptelea trifoliata</i> (Oldham-ER-1983).
3. Fish Point, Pelee Township (41°44'N, 82°41'W)	Dry upland deciduous-evergreen forest — sand — <i>Quercus velutina</i> – <i>Juniperus virginiana</i> – <i>Fraxinus americana</i> / <i>Celtis occidentalis</i> – <i>Ostrya virginiana</i> – <i>Fraxinus quadrangulata</i> – <i>Ulmus americana</i> – <i>Quercus muhlenbergii</i> – <i>Prunus virginiana</i> – <i>Morus rubra</i> – <i>Platanus occidentalis</i> – <i>Ptelea trifoliata</i> (Maycock-145-1970). Dry upland deciduous forest — sand — <i>Celtis occidentalis</i> – <i>Fraxinus quadrangulata</i> / <i>Acer saccharum</i> – <i>Prunus virginiana</i> – <i>Quercus velutina</i> – <i>Q. muhlenbergii</i> – <i>Juniperus virginiana</i> – <i>Morus rubra</i> – <i>Tilia americana</i> (Maycock-36P-1970). Dry-mesic upland deciduous forest — sand — <i>Celtis occidentalis</i> – <i>Fraxinus americana</i> – <i>F. quadrangulata</i> – <i>Acer saccharum</i> / <i>Quercus velutina</i> – <i>Q. muhlenbergii</i> – <i>Prunus virginiana</i> – <i>Tilia americana</i> – <i>Morus rubra</i> – <i>Juniperus virginiana</i> (Maycock-143-1970). Dry-mesic upland deciduous forest — sand — <i>Acer saccharum</i> – <i>Fraxinus americana</i> – <i>Celtis occidentalis</i> – <i>Quercus muhlenbergii</i> / <i>Ostrya virginiana</i> – <i>Juniperus virginiana</i> – <i>Ulmus americana</i> – <i>Morus rubra</i> (Maycock-38P-1970). Wet lowland deciduous forest — sand — <i>Fraxinus pennsylvanica</i> – <i>Ulmus americana</i> / <i>Quercus macrocarpa</i> – <i>Tilia americana</i> (Maycock-40P-1970). Very dry upland tall thicket — sand — <i>Ptelea trifoliata</i> / <i>Juniperus virginiana</i> – <i>Quercus velutina</i> – <i>Prunus virginiana</i> (Maycock-14603-1970). Saturated tall shrub carr — muck-sand — <i>Cephalanthus occidentalis</i> – <i>Decodon verticillata</i> (Walshe-IBP-1970). Open water emergent aquatic — muck-sand — <i>Nuphar advena</i> – <i>Nelumbo lutea</i> (Walshe-IBP-1970).
4. McCormick's Woods, Pelee Township (41°44'N, 82°42'W)	Wet lowland deciduous forest — clay — <i>Acer saccharinum</i> – <i>A. rubrum</i> – <i>Fraxinus pennsylvanica</i> – <i>Carya ovata</i> – <i>Fraxinus americana</i> – <i>Quercus muhlenbergii</i> – <i>Populus deltoides</i> – <i>Fraxinus nigra</i> – <i>Quercus macrocarpa</i> – <i>Carya laciniosa</i> (Maycock-144-1970).
5. Middle Point, Pelee Township (41°48'N, 82°38'W)	Bottomland – lowland deciduous forest complex behind shore dune — sand — <i>Acer saccharinum</i> – <i>Fraxinus pennsylvanica</i> – <i>Carya ovata</i> / <i>Tilia americana</i> (Maycock and Oldham-obs-1984).
6. Red Cedar Savanna, Pelee Township (41°45'N, 82°41'W)	Very dry temperate coniferous-deciduous savanna — limestone — <i>Juniperus virginiana</i> – <i>Celtis occidentalis</i> – <i>Celtis tenuifolia</i> – <i>Morus rubra</i> (Oldham-ER-1983).

(continued)

TABLE I. Continued

Location	Vegetation
7. Lighthouse Point, Pelee Township (41°49'N, 82°38'W)	Temperate deciduous-savanna — clay — <i>Celtis occidentalis</i> — <i>Fraxinus quadrangulata</i> — <i>Quercus prinoides</i> — <i>Crataegus mollis</i> — <i>Tilia americana</i> — <i>Ostrya virginiana</i> (Oldham-ER-1983, Maycock-Fahselt-Oldham-obs-1984). Open dune forest — sand — <i>Populus deltoides</i> — <i>Fraxinus pennsylvanica</i> — <i>Salix amygdaloides</i> — <i>Cornus racemosa</i> (Walshe-IBP-1970; Oldham-ER-1983). Sand prairie — <i>Panicum virgatum</i> — <i>Salsola kali</i> (Walshe-IBP-1970). Marsh — sand — <i>Nelumbo lutea</i> — <i>Typha latifolia</i> — <i>Lemna minor</i> (Walshe-IBP-1970).
8. Sheridan Point, Pelee Township (41°48'N, 82°42'W)	Dry upland deciduous-coniferous forest — sand — <i>Celtis occidentalis</i> — <i>Juniperus virginiana</i> — <i>Juglans nigra</i> — <i>Crataegus</i> sp. (Maycock & Oldham-obs-1984).
9. Stone Road, Prairie-Alvar (41°45'N, 82°38'W)	Dry mesic tallgrass prairie — sand-rock — <i>Poa compressa</i> — <i>Fragaria virginiana</i> — <i>Poa pratensis</i> — <i>Andropogon gerardi</i> — <i>Senecio plattensis</i> — <i>Ratibida pinnata</i> (Maycock & Oldham-6122-1984). Dry upland deciduous savanna — sand-rock — <i>Quercus muhlenbergii</i> — <i>Q. macrocarpa</i> — <i>Q. alba</i> — <i>Carya ovata</i> — <i>Fraxinus americana</i> — <i>F. quadrangulata</i> (Maycock & Fahselt-obs-1984; Oldham-ER-1983). Dry low thickets — sand-rock — <i>Rhus aromatica</i> — <i>Rosa setigera</i> — <i>Rubus allegheniensis</i> — <i>Rubus occidentalis</i> (Maycock & Fahselt-obs-1984). Dry tall thickets — sand-rock — <i>Cornus racemosa</i> — <i>Rhus aromatica</i> — <i>Viburnum rafinesquianum</i> — <i>Rhus radicans</i> — <i>Amelanchier humilis</i> — <i>Xanthoxylum americanum</i> — <i>Rubus allegheniensis</i> (Maycock & Fahselt-obs-1984; Oldham-ER-1983).
10. Point Pelee National Park, Mersea Township (41°58'N, 82°31'W)	Very dry open evergreen savanna — sand — <i>Juniperus virginiana</i> / <i>Prunus virginiana</i> — <i>Juglans nigra</i> (Maycock-16002-1959) Very dry open evergreen-deciduous savanna — sand — <i>Juniperus virginiana</i> — <i>Populus deltoides</i> / <i>Salix alba</i> — <i>Celtis occidentalis</i> (Maycock-16005-1969) Very dry open evergreen-deciduous savanna — sand — <i>Juniperus virginiana</i> — <i>Salix alba</i> — <i>Populus deltoides</i> / <i>Ptelea trifoliata</i> — <i>Celtis occidentalis</i> — <i>Quercus velutina</i> — <i>Prunus virginiana</i> — <i>Morus rubra</i> (Maycock-16006-1969). Dry upland evergreen-deciduous forest — sand — <i>Juniperus virginiana</i> — <i>Celtis occidentalis</i> / <i>Quercus rubra</i> — <i>Pinus strobus</i> — <i>Prunus virginiana</i> — <i>Quercus velutina</i> — <i>Ostrya virginiana</i> (Maycock-55-1958). Dry upland deciduous-evergreen forest — sand — <i>Celtis occidentalis</i> — <i>Juniperus virginiana</i> / <i>Juglans nigra</i> — <i>Quercus macrocarpa</i> — <i>Tilia americana</i> — <i>Ostrya virginiana</i> — <i>Quercus rubra</i> — <i>Prunus virginiana</i> (Maycock-7P-1969). Dry upland deciduous-evergreen forest — sand — <i>Celtis occidentalis</i> — <i>Juniperus virginiana</i> — <i>Quercus rubra</i> / <i>Tilia americana</i> — <i>Pinus strobus</i> — <i>Ostrya virginiana</i> — <i>Juglans nigra</i> — <i>J. cinerea</i> — <i>Prunus virginiana</i> (Maycock-6P-1969). Dry upland deciduous-evergreen forest — sand — <i>Celtis occidentalis</i> — <i>Juniperus virginiana</i> — <i>Ostrya virginiana</i> — <i>Pinus strobus</i> — <i>Quercus rubra</i> / <i>Prunus virginiana</i> — <i>Fraxinus americana</i> — <i>Tilia americana</i> (Maycock-IP-1969) Dry upland deciduous-evergreen forest — sand — <i>Celtis occidentalis</i> — <i>Pinus strobus</i> / <i>Juniperus virginiana</i> — <i>Quercus rubra</i> — <i>Prunus virginiana</i> — <i>Juglans nigra</i> — <i>Ostrya virginiana</i> — <i>Tilia americana</i> — <i>Quercus muhlenbergii</i> (Maycock-2P-1969). Dry-mesic upland evergreen-deciduous forest — sand — <i>Juniperus virginiana</i> — <i>Ostrya virginiana</i> — <i>Quercus rubra</i> / <i>Prunus virginiana</i> — <i>Quercus velutina</i> — <i>Q. muhlenbergii</i> — <i>Tilia americana</i> (Maycock-9P-1969). Dry-mesic upland evergreen-deciduous forest — sand — <i>Juniperus virginiana</i> — <i>Quercus rubra</i> — <i>Prunus virginiana</i> — <i>Quercus velutina</i> — <i>Ostrya virginiana</i> / <i>Celtis occidentalis</i> — <i>Quercus muhlenbergii</i> — <i>Tilia americana</i> — <i>Amelanchier arborea</i> (Maycock-140-1969). Dry-mesic upland deciduous-evergreen forest — sand — <i>Celtis occidentalis</i> — <i>Juniperus virginiana</i> / <i>Quercus muhlenbergii</i> — <i>Q. rubra</i> — <i>Ostrya virginiana</i> — <i>Prunus virginiana</i> — <i>Juglans nigra</i> — <i>Tilia americana</i> — <i>Quercus velutina</i> (Maycock-33P-1970). Dry-mesic upland deciduous-evergreen forest — sand — <i>Celtis occidentalis</i> — <i>Juniperus virginiana</i> / <i>Morus rubra</i> — <i>Acer saccharum</i> — <i>Juglans nigra</i> — <i>Tilia americana</i> (Maycock-14P-1969).

(continued)

TABLE I. Continued

Location	Vegetation
10. (Continued)	<p>Dry-mesic upland deciduous-evergreen forest — sand — <i>Celtis occidentalis</i> - <i>Fraxinus quadrangulata</i> - <i>Acer saccharum</i> - <i>Tilia americana</i> / <i>Juniperus virginiana</i> - <i>Juglans cinerea</i> - <i>Quercus rubra</i> - <i>Juglans nigra</i> - <i>Morus rubra</i> (Maycock-15P-1969).</p> <p>Dry-mesic upland deciduous-evergreen forest — sand — <i>Celtis occidentalis</i> - <i>Juniperus virginiana</i> - <i>Pinus strobus</i> - <i>Quercus rubra</i> - <i>Ostrya virginiana</i> / <i>Acer saccharum</i> - <i>Prunus virginiana</i> - <i>Fraxinus americana</i> - <i>Juglans nigra</i> - <i>Rhus typhina</i> (Maycock-13P-1969).</p> <p>Dry-mesic upland deciduous-evergreen forest — sand — <i>Celtis occidentalis</i> - <i>Juniperus virginiana</i> - <i>Juglans nigra</i> - <i>Quercus muhlenbergii</i> - <i>Q. rubra</i> - <i>Tilia americana</i> / <i>Ostrya virginiana</i> - <i>Fraxinus americana</i> (Maycock-56-1958).</p> <p>Dry-mesic upland deciduous-evergreen forest — sand — <i>Quercus velutina</i> - <i>Juniperus virginiana</i> - <i>Pinus strobus</i> - <i>Ostrya virginiana</i> / <i>Prunus virginiana</i> - <i>Quercus rubra</i> - <i>Juglans nigra</i> - <i>Carya ovata</i> - <i>Fraxinus pennsylvanica</i> (Maycock-11P-1969).</p> <p>Dry-mesic upland deciduous-evergreen forest — <i>Acer saccharum</i> - <i>Juniperus virginiana</i> - <i>Celtis occidentalis</i> / <i>Prunus virginiana</i> - <i>Juglans nigra</i> - <i>Tilia americana</i> - <i>Fraxinus quadrangulata</i> - <i>Prunus serotina</i> - <i>Quercus muhlenbergii</i> (Maycock-12P-1969).</p> <p>Mesic upland deciduous-evergreen forest — sand — <i>Celtis occidentalis</i> - <i>Quercus rubra</i> - <i>Tilia americana</i> / <i>Juniperus virginiana</i> - <i>Ostrya virginiana</i> - <i>Quercus muhlenbergii</i> - <i>Prunus virginiana</i> - <i>Juglans nigra</i> - <i>Fraxinus americana</i> - <i>Carya ovata</i> (Maycock-17P-1969).</p> <p>Mesic upland deciduous forest — sand — <i>Celtis occidentalis</i> - <i>Juglans nigra</i> / <i>Quercus muhlenbergii</i> - <i>Fraxinus quadrangulata</i> - <i>Tilia americana</i> - <i>Quercus macrocarpa</i> - <i>Q. rubra</i> - <i>Juniperus virginiana</i> - <i>Prunus virginiana</i> - <i>Morus rubra</i> - <i>Acer saccharum</i> (Maycock-18P-1969).</p> <p>Mesic upland deciduous forest — sand — <i>Celtis occidentalis</i> - <i>Ulmus americana</i> - <i>Tilia americana</i> / <i>Carya ovata</i> - <i>Acer saccharinum</i> - <i>Fraxinus americana</i> - <i>Quercus rubra</i> - <i>Prunus virginiana</i> - <i>Platanus occidentalis</i> - <i>Fraxinus pennsylvanica</i> (Maycock-21P-1970).</p> <p>Mesic upland deciduous forest — sand — <i>Celtis occidentalis</i> - <i>Ulmus americana</i> / <i>Tilia americana</i> - <i>Juglans nigra</i> - <i>Carya ovata</i> - <i>Fraxinus pennsylvanica</i> - <i>Quercus rubra</i> - <i>Fraxinus americana</i> - <i>Carya cordiformis</i> - <i>Quercus muhlenbergii</i> (Maycock-28P-1970).</p> <p>Mesic upland deciduous forest — sand — <i>Celtis occidentalis</i> - <i>Ulmus americana</i> - <i>Quercus rubra</i> - <i>Carya ovata</i> - <i>Acer saccharinum</i> - <i>A. rubrum</i> / <i>Quercus muhlenbergii</i> - <i>Tilia americana</i> - <i>Ostrya virginiana</i> - <i>Prunus virginiana</i> (Maycock-23P-1970).</p> <p>Mesic upland deciduous forest — sand — <i>Fraxinus americana</i> - <i>Tilia americana</i> - <i>Celtis occidentalis</i> / <i>Juglans nigra</i> - <i>Quercus muhlenbergii</i> - <i>Ostrya virginiana</i> - <i>Quercus rubra</i> - <i>Sassafras albidum</i> - <i>Carya ovata</i> - <i>Prunus virginiana</i> (Maycock-31P-1970).</p> <p>Wet-mesic lowland deciduous forest — sand — <i>Celtis occidentalis</i> - <i>Ulmus americana</i> - <i>Tilia americana</i> - <i>Acer saccharinum</i> / <i>Fraxinus nigra</i> - <i>F. pennsylvanica</i> - <i>Ostrya virginiana</i> - <i>Juglans nigra</i> - <i>Prunus virginiana</i> - <i>Fraxinus americana</i> (Maycock-27P-1970).</p> <p>Wet-mesic lowland deciduous forest — sand — <i>Celtis occidentalis</i> - <i>Fraxinus pennsylvanica</i> - <i>Ulmus americana</i> - <i>Carya ovata</i> / <i>Platanus occidentalis</i> - <i>Quercus muhlenbergii</i> - <i>Ostrya virginiana</i> - <i>Tilia americana</i> - <i>Cornus drummondii</i> (Maycock-22P-1970).</p> <p>Wet-mesic lowland deciduous forest — sand — <i>Celtis occidentalis</i> - <i>Fraxinus americana</i> - <i>Acer saccharinum</i> / <i>Platanus occidentalis</i> - <i>Fraxinus pennsylvanica</i> - <i>Ulmus americana</i> - <i>Tilia americana</i> - <i>Carya ovata</i> - <i>Prunus virginiana</i> (Maycock-26P-1970).</p> <p>Wet-mesic lowland deciduous forest — sand — <i>Celtis occidentalis</i> - <i>Acer saccharinum</i> - <i>Carya ovata</i> - <i>Ulmus americana</i> / <i>Ostrya virginiana</i> - <i>Quercus rubra</i> - <i>Juglans nigra</i> - <i>Sassafras albidum</i> - <i>Quercus muhlenbergii</i> - <i>Prunus virginiana</i> - <i>Tilia americana</i> - <i>Carya cordiformis</i> (Maycock-32P-1970).</p> <p>Wet lowland-bottomland deciduous forest — organic — <i>Fraxinus pennsylvanica</i> - <i>Ulmus americana</i> / <i>Celtis occidentalis</i> - <i>Fraxinus americana</i> - <i>Quercus macrocarpa</i> - <i>Tilia americana</i> - <i>Acer saccharinum</i> (Maycock-30P-1970).</p>

(continued)

TABLE 1. Continued

Location	Vegetation
10. (Continued)	Wet lowland-bottomland deciduous forest — organic — <i>Fraxinus pennsylvanica</i> — <i>Ulmus americana</i> — <i>Acer saccharinum</i> / <i>Fraxinus nigra</i> — <i>Celtis occidentalis</i> — <i>Quercus macrocarpa</i> — <i>Tilia americana</i> — <i>Gleditsia triacanthos</i> (Maycock-25P-1970).
	Wet lowland-bottomland deciduous forest — organic — <i>Acer saccharinum</i> — <i>Ulmus americana</i> — <i>Fraxinus pennsylvanica</i> / <i>Tilia americana</i> — <i>Celtis occidentalis</i> — <i>Quercus muhlenbergii</i> — <i>Carya ovata</i> — <i>Quercus bicolor</i> — <i>Q. macrocarpa</i> — <i>Lindera benzoin</i> — <i>Prunus virginiana</i> (Maycock-20P-1970).
	Wet lowland deciduous forest — organic — <i>Salix amygdaloides</i> — <i>Populus deltoides</i> / <i>Salix eriocephala</i> — <i>Rhus typhina</i> — <i>Ulmus americana</i> — <i>Salix nigra</i> — <i>Fraxinus pennsylvanica</i> — <i>Celtis occidentalis</i> — <i>Juglans nigra</i> (Maycock-142-1970).
	Very wet bottomland-lowland deciduous forest — organic — <i>Acer saccharinum</i> — <i>Fraxinus pennsylvanica</i> — <i>Ulmus americana</i> / <i>Fraxinus nigra</i> — <i>Populus deltoides</i> — <i>Tilia americana</i> — <i>Quercus macrocarpa</i> — <i>Celtis occidentalis</i> (Maycock-24P-1970).
	Wet bottomland-lowland deciduous forest — sand — <i>Ulmus americana</i> — <i>Celtis occidentalis</i> — <i>Fraxinus pennsylvanica</i> / <i>Tilia americana</i> — <i>Acer saccharinum</i> — <i>Platanus occidentalis</i> — <i>Quercus macrocarpa</i> — <i>Carya ovata</i> — <i>Carpinus caroliniana</i> — <i>Juglans nigra</i> — <i>Populus deltoides</i> — <i>Prunus virginiana</i> — <i>Lindera benzoin</i> (Maycock-19P-1970).
	Dry upland pine forest — sand — <i>Pinus strobus</i> / <i>Celtis occidentalis</i> — <i>Juniperus virginiana</i> — <i>Ostrya virginiana</i> (Maycock-13PR-1958).
	Dry open foredune beach — sand — <i>Xanthium strumarium</i> — <i>Strophostyles helvola</i> — <i>Euphorbia polygonifolia</i> — <i>Cakile edentula</i> — <i>Triplasis purpurea</i> (Maycock-13021-1976).
	Very dry open cactus barrens — sand — <i>Sporobolus cryptandrus</i> — <i>Poa compressa</i> — <i>Opuntia humifusa</i> — <i>Poa pratensis</i> — <i>Asclepias syriaca</i> (Maycock-X-1976).
	Dry upland tall shrub thicket — sand — <i>Ptelea trifoliata</i> — <i>Vitis riparia</i> — <i>Rhus aromatica</i> (Maycock-14602-1970).
	Dry upland tall shrub thicket — sand — <i>Prunus virginiana</i> — <i>Ptelea trifoliata</i> — <i>Juniperus communis</i> — <i>Ribes cynosbati</i> — <i>Symphoricarpos albus</i> (Maycock-14604-1971).
	Wet dune-slack-fen — sand — <i>Eleocharis elliptica</i> — <i>Panicum virgatum</i> — <i>Eupatorium perfoliatum</i> — <i>Juncus torreyi</i> — <i>Lobelia siphilitica</i> (Maycock-10704-1977).
	Saturated dune-slack marsh — sand — <i>Lemna minor</i> — <i>Glyceria striata</i> — <i>Scutellaria lateriflora</i> — <i>Impatiens capensis</i> — <i>Leersia oryzoides</i> (Maycock-X-1970).
11. Sturgeon Creek, Mersea Township (42°02'N, 82°35'W)	Wet-mesic lowland deciduous forest — dry — <i>Acer saccharum</i> — <i>Quercus rubra</i> / <i>Fraxinus americana</i> — <i>Ulmus americana</i> — <i>Acer saccharinum</i> — <i>Tilia americana</i> — <i>Platanus occidentalis</i> — <i>Prunus serotina</i> — <i>Liriodendron tulipifera</i> — <i>Celtis occidentalis</i> — <i>Carya cordiformis</i> — <i>Sassafras albidum</i> — <i>Quercus macrocarpa</i> (Maycock-136-1970).
12. Leamington Sand Hills, Mersea Township (42°04'N, 82°32'W)	Wet-mesic upland deciduous forest — sand — <i>Quercus rubra</i> — <i>Q. alba</i> / <i>Acer rubrum</i> — <i>Acer saccharinum</i> — <i>Fraxinus pennsylvanicum</i> — <i>Sassafras albidum</i> — <i>Liriodendron tulipifera</i> (Walshe-IBP-1970, Oldham-ER-1983).
13. Leamington Beech Woods, Mersea Township (42°04'N, 82°34'W)	Mesic upland deciduous forest — loam — <i>Fagus grandifolia</i> — <i>Acer saccharum</i> — <i>Ulmus americana</i> — <i>Fraxinus americana</i> / <i>Juglans cinerea</i> — <i>Acer rubrum</i> — <i>Tilia americana</i> — <i>Betula lutea</i> — <i>Liriodendron tulipifera</i> — <i>Quercus rubra</i> — <i>Prunus serotina</i> (Maycock-54-1958).
14. Leamington White Oak Woods, Mersea Township (42°06'N, 82°32'W)	Dry-mesic upland deciduous forest — sand — <i>Quercus alba</i> — <i>Q. velutina</i> — <i>Liriodendron tulipifera</i> — <i>Sassafras albidum</i> — <i>Cornus florida</i> — <i>Castanea dentata</i> (Oldham-ER-1983).
15. Wigle, Mersea Township (42°07'N, 82°38'W)	Wet-mesic lowland deciduous forest — sand — <i>Ulmus americana</i> — <i>Quercus rubra</i> — <i>Q. palustris</i> — <i>Acer rubrum</i> — <i>Q. bicolor</i> — <i>Fraxinus americana</i> / <i>F. pennsylvanica</i> — <i>Carya ovata</i> — <i>Platanus occidentalis</i> — <i>Sassafras albidum</i> — <i>Prunus serotina</i> — <i>Acer saccharinum</i> (Maycock-53-1958; Walshe-IBP-1970).
	Dry upland deciduous forest — sand — <i>Quercus rubra</i> — <i>Q. alba</i> — <i>Acer rubrum</i> — <i>Sassafras albidum</i> — <i>Liriodendron tulipifera</i> (Walshe-IBP-1970).

(continued)

TABLE I. Continued

Location	Vegetation
16. Mount Carmel, Mersea Township (42°07'N, 82°31'W)	Wet lowland deciduous forest — muck — <i>Quercus palustris</i> – <i>Acer rubrum</i> – <i>Ulmus americana</i> / <i>Populus deltoides</i> – <i>Quercus bicolor</i> – <i>Nyssa sylvatica</i> – <i>Fraxinus pennsylvanica</i> – <i>Acer saccharinum</i> – <i>Quercus rubra</i> – <i>Salix amygdaloides</i> – <i>Fraxinus nigra</i> (Maycock-52-1958).
17. Cameron Scott's Woods, Mersea Township (42°07'N, 82°39'W)	Wet lowland deciduous forest — sand — <i>Fraxinus pennsylvanica</i> – <i>Acer saccharinum</i> / <i>Quercus bicolor</i> – <i>Q. palustris</i> – <i>Platanus occidentalis</i> – <i>Nyssa sylvatica</i> (Walshe-IBP-1970). Dry upland deciduous forest — sand — <i>Quercus rubra</i> – <i>Q. alba</i> – <i>Acer rubrum</i> / <i>Sassafras albidum</i> – <i>Liriodendron tulipifera</i> (Walshe-IBP-1970).
18. Hillman Oak-Tulip, Mersea Township (42°03'N, 82°31'W)	Mesic upland deciduous forest — sand — <i>Acer saccharum</i> – <i>Fraxinus pennsylvanica</i> / <i>Fagus grandifolia</i> – <i>Tilia americana</i> – <i>Liriodendron tulipifera</i> – <i>Sassafras albidum</i> – <i>Carya ovata</i> (Walshe-IBP-1970; Oldham-ER-1983).
19. Hillman, Mersea Township (42°03'N, 82°33'W)	Dry-mesic upland deciduous forest — sand — <i>Quercus alba</i> – <i>Liriodendron tulipifera</i> – <i>Quercus rubra</i> – <i>Sassafras albidum</i> – <i>Prunus serotina</i> / <i>Acer rubrum</i> – <i>Fraxinus americana</i> – <i>Populus tremuloides</i> – <i>Tilia americana</i> – <i>Cornus florida</i> (Maycock-73-1959)
20. Hillman Marsh, Mersea Township (41°02'N, 82°30'W)	Saturated marsh — sand — <i>Typha latifolia</i> (Oldham-ER-1983).
21. Wheatley Sand Hills, Mersea Township (42°04'N, 82°31'W)	Dry upland deciduous forest — sand — <i>Quercus rubra</i> – <i>Q. alba</i> / <i>Fagus grandifolia</i> – <i>Quercus velutina</i> – <i>Sassafras albidum</i> – <i>Castanea dentata</i> (Walshe-IBP-1970). Wet lowland deciduous forest — sand — <i>Acer saccharinum</i> – <i>Fraxinus pennsylvanica</i> / <i>Quercus palustris</i> – <i>Nyssa sylvatica</i> – <i>Quercus bicolor</i> (Walshe-IBP-1970; Oldham-ER-1983).
22. Kopegaron Woods, Mersea Township (42°05'N, 82°30'W)	Dry upland deciduous forest — sand — <i>Quercus rubra</i> – <i>Acer rubrum</i> – <i>Sassafras albidum</i> – <i>Cornus florida</i> – <i>Quercus velutina</i> – <i>Liriodendron tulipifera</i> – <i>Castanea dentata</i> (Oldham-ER-1983). Wet lowland deciduous forest — clay — <i>Fraxinus pennsylvanica</i> – <i>Ulmus americana</i> – <i>Quercus bicolor</i> – <i>Acer saccharinum</i> – <i>Quercus palustris</i> – <i>Platanus occidentalis</i> – <i>Nyssa sylvatica</i> (Oldham-ER-1983)
23. Arner Lowland Forest, Gosfield South Township (42°03'N, 82°49'W)	Wet-mesic lowland deciduous forest — clay — <i>Quercus palustris</i> – <i>Q. rubra</i> – <i>Q. alba</i> – <i>Fraxinus americana</i> – <i>Ulmus americana</i> – <i>Ostrya virginiana</i> (Oldham-ER-1983).
24. Arner Spleenwort Woods, South Colchester Township (42°02'N, 82°53'W)	Mesic upland deciduous forest — sand — <i>Fagus grandifolia</i> – <i>Acer saccharum</i> – <i>Carya cordiformis</i> – <i>Tilia americana</i> – <i>Liriodendron tulipifera</i> – <i>Sassafras albidum</i> – <i>Ostrya virginiana</i> – <i>Juglans cinerea</i> (Oldham-ER-1983).
25. Colchester Sand Plain, South Colchester Township (42°01'N, 82°55'W)	Mesic upland deciduous forest — sand — <i>Quercus rubra</i> – <i>Acer rubrum</i> – <i>Quercus alba</i> – <i>Fraxinus pennsylvanica</i> / <i>Sassafras albidum</i> – <i>Carya ovata</i> – <i>C. glabra</i> – <i>C. cordiformis</i> – <i>Prunus serotina</i> – <i>Quercus mulhenbergii</i> (Walshe-IBP-1970). Wet lowland deciduous forest — sand — <i>Acer rubrum</i> – <i>Fraxinus pennsylvanica</i> – <i>Quercus alba</i> / <i>Ulmus americana</i> – <i>Juglans nigra</i> – <i>Juniperus virginiana</i> (Walshe-IBP-1970).
26. Marshfield Clay Plain, South Colchester Township (42°04'N, 82°53'W)	Wet lowland deciduous forest — clay — <i>Quercus palustris</i> – <i>Q. bicolor</i> / <i>Fraxinus pennsylvanica</i> – <i>Populus deltoides</i> – <i>Ulmus americana</i> (Walshe-IBP-1970).
27. Harrow, South Colchester Township (42°00'N, 82°53'W)	Wet-mesic lowland deciduous forest — loam — <i>Quercus rubra</i> – <i>Fraxinus americana</i> – <i>Ostrya virginiana</i> – <i>Ulmus rubra</i> – <i>U. americana</i> / <i>Carya ovata</i> – <i>C. cordiformis</i> – <i>Quercus alba</i> – <i>Juglans nigra</i> – <i>Liriodendron tulipifera</i> – <i>Fagus grandifolia</i> – <i>Juglans cinerea</i> – <i>Sassafras albidum</i> – <i>Quercus macrocarpa</i> – <i>Q. velutina</i> – <i>Fraxinus pennsylvanica</i> (Maycock-74-1959).

(continued)

TABLE I. Continued

Location	Vegetation
28. Cedar Creek, South Colchester Township (42°02'N, 82°50'W)	Wet floodplain deciduous forest — clay — <i>Acer saccharinum</i> – <i>Ulmus americana</i> (Walshe-IBP-1970; Oldham-ER-1983). Wet lowland deciduous forest — clay — <i>Quercus palustris</i> – <i>Q. bicolor</i> – <i>Carya ovata</i> – <i>Fraxinus pennsylvanica</i> (Walshe-IBP-1970; Oldham-ER-1983).
29. Oxley, South Colchester Township (42°00'N, 82°52'W)	Very wet lowland tall shrub carr — organic — <i>Rhus vernix</i> – <i>Cornus racemosa</i> (Oldham-ER-1983). Wet lowland deciduous forest — sand — <i>Betula lutea</i> – <i>Acer rubrum</i> – <i>Acer saccharum</i> – <i>Fraxinus americana</i> – <i>Prunus serotina</i> – <i>Celtis occidentalis</i> (Oldham-ER-1983).
30. Barretville Clay Plain, North Colchester Township (42°06'N, 82°55'W)	Wet lowland deciduous forest — clay — <i>Quercus palustris</i> – <i>Fraxinus pennsylvanica</i> – <i>Q. bicolor</i> – <i>Populus deltoides</i> – <i>Ulmus americana</i> – <i>Acer saccharinum</i> (Walshe-IBP-1970).
31. Big Creek Marsh, Malden Township (42°03'N, 83°04'W)	Wet-mesic upland deciduous forest — clay — <i>Celtis occidentalis</i> / <i>Quercus rubra</i> – <i>Carya ovata</i> – <i>C. ovalis</i> (Walshe-IBP-1970). Very wet tall thicket — muck — <i>Cornus racemosa</i> – <i>Sambucus canadensis</i> (Walshe-IBP-1970). Saturated shrub carr — organic — <i>Cephalanthus occidentalis</i> – <i>Decodon verticillatus</i> (Walshe-IBP-1970). Saturated marsh — organic — <i>Typha latifolia</i> – <i>Sparganium eurycarpum</i> – <i>Phragmites communis</i> (Walshe-IBP-1970; Oldham-ER-1983). Floating aquatic — organic — <i>Nymphaea odorata</i> (Walshe-IBP-1970). Emergent aquatic — organic — <i>Nelumbo lutea</i> (Walshe-IBP-1980).
32. Upper Big Creek, Anderdon Township (42°07'N, 83°05'W)	Wet bottomland deciduous forest — loam — <i>Fraxinus pennsylvanica</i> – <i>Ulmus rubra</i> – <i>Acer saccharinum</i> – <i>Crataegus</i> spp. – <i>Juglans nigra</i> – <i>Quercus palustris</i> (Oldham-ER-1983).
33. Amherstburg, Anderdon Township (42°06'N, 83°05'W)	Wet-mesic lowland deciduous forest — clay — <i>Quercus macrocarpa</i> – <i>Q. bicolor</i> – <i>Carya ovata</i> / <i>Juglans nigra</i> – <i>Ulmus americana</i> – <i>Fraxinus pennsylvanica</i> – <i>Quercus rubra</i> – <i>Carya cordiformis</i> – <i>Ulmus rubra</i> – <i>Tilia americana</i> – <i>Quercus alba</i> (Maycock-75-1959).
34. Canard River Bottoms, Anderdon Township (42°07'N, 82°58'W)	Wet bottomland deciduous forest — clay — <i>Fraxinus americana</i> – <i>Crataegus punctata</i> – <i>Ulmus americana</i> / <i>Gymnocladus dioica</i> – <i>Tilia americana</i> – <i>Quercus macrocarpa</i> – <i>Ostrya virginiana</i> – <i>Fraxinus pennsylvanica</i> – <i>Quercus rubra</i> – <i>Carya cordiformis</i> – <i>Acer saccharum</i> – <i>Ulmus rubra</i> – <i>Fagus grandifolia</i> (Maycock-180-1984; Oldham-ER-1983).
35. Canard River Scout Camp, Anderdon Township (42°10'N, 83°02'W)	Drier upland deciduous forest — clay — <i>Quercus</i> spp. – <i>Carya ovata</i> – <i>Acer saccharum</i> (Oldham-ER-1983). Wet bottomland deciduous forest — clay — <i>Acer saccharinum</i> – <i>Fraxinus pennsylvanica</i> (Oldham-ER-1983).
36. Canard River mouth marsh Anderdon Township (42°10'N, 83°07'W)	Saturated emergent marsh — organic — <i>Typha latifolia</i> (Oldham-ER-1983). Open water floating aquatic — organic — <i>Nuphar advena</i> (Oldham-ER-1983).
37. Splitlog, Anderdon Township (42°08'N, 83°07'W)	Wet mesic lowland deciduous forest — clay — <i>Quercus rubra</i> – <i>Q. bicolor</i> – <i>Fraxinus americana</i> – <i>Ulmus americana</i> / <i>Quercus palustris</i> – <i>Carya cordiformis</i> – <i>Quercus macrocarpa</i> – <i>Q. alba</i> – <i>Ulmus rubra</i> – <i>Carya ovata</i> – <i>Tilia americana</i> – <i>Juglans nigra</i> – <i>Populus deltoides</i> – <i>Cornus florida</i> (Maycock-57-1958).
38. Devonwood, Windsor Township (42°16'N, 82°58'W)	Wet lowland deciduous forest — loam — <i>Fraxinus pennsylvanica</i> – <i>F. americana</i> – <i>Ulmus americana</i> – <i>Quercus rubra</i> – <i>Q. palustris</i> – <i>Q. macrocarpa</i> – <i>Carya ovata</i> – <i>Acer saccharinum</i> – <i>Platanus occidentalis</i> – <i>Populus deltoides</i> (Oldham-ER-1983).
39. Ojibway West, Windsor Township (42°17'N, 83°05'W)	Dry upland savanna-like deciduous forest — sand — <i>Quercus velutina</i> (Oldham-ER-1983).

(continued)

TABLE I. Continued

Location	Vegetation
40. Sandwich West, Sandwich West Township (42°14'N, 83°03'W)	Dry upland deciduous forest — sand — <i>Quercus velutina</i> — <i>Q. rubra</i> — <i>Q. alba</i> — <i>Carya ovalis</i> — <i>Castanea dentata</i> (Oldham-ER-1983). Wet lowland deciduous forest — sand — <i>Quercus palustris</i> — <i>Q. macrocarpa</i> — <i>Q. bicolor</i> — <i>Carya laciniosa</i> (Oldham-ER-1983).
41. Ojibway, Windsor Township (42°16'N, 83°04'W)	Wet lowland deciduous forest — sand — <i>Quercus palustris</i> — <i>Ulmus americana</i> — <i>Acer rubrum</i> / <i>Prunus serotina</i> — <i>Quercus bicolor</i> — <i>Acer saccharinum</i> — <i>Quercus macrocarpa</i> — <i>Populus deltoides</i> — <i>Quercus rubra</i> — <i>Carya ovata</i> — <i>Fraxinus pennsylvanica</i> — <i>Crataegus</i> spp. (Maycock-112-1960). Wet-mesic lowland deciduous temperate savanna — sand — <i>Quercus palustris</i> / <i>Q. alba</i> — <i>Q. macrocarpa</i> — <i>Populus deltoides</i> — <i>Carya ovalis</i> — <i>Acer saccharinum</i> — <i>Quercus bicolor</i> — <i>Fraxinus pennsylvanica</i> (Maycock-16007-1973). Dry upland deciduous temperate savanna — sand — <i>Quercus velutina</i> — <i>Q. rubra</i> — <i>Q. macrocarpa</i> (Maycock-obs-1973). Dry upland tallgrass prairie — sand — <i>Poa compressa</i> — <i>Poa pratensis</i> — <i>Aster ericoides</i> — <i>Rubus flagellaris</i> — <i>Lespedeza capitata</i> — <i>Panicum oligosanthos</i> (Langendoen-6075-1982). Dry upland tallgrass prairie — sand — <i>Sorghastrum nutans</i> — <i>Solidago nemoralis</i> — <i>Coreopsis tripteris</i> — <i>Lespedeza capitata</i> — <i>Euphorbia corollata</i> (Maycock & Ball-6015-1969). Dry mesic upland tallgrass prairie — sand — <i>Poa compressa</i> — <i>Panicum virgatum</i> — <i>Solidago canadensis</i> — <i>Aster ericoides</i> — <i>Aristida purpurascens</i> (Maycock & Ball-6018-1971). Dry-mesic upland tallgrass prairie — sand — <i>Scleria triglomerata</i> — <i>Solidago juncea</i> — <i>Aristida purpurascens</i> — <i>Silphium terebinthinaceum</i> — <i>Aster ericoides</i> (Maycock & Langendoen-6020-1982). Dry-mesic upland tallgrass prairie — sand — <i>Euphorbia corollata</i> — <i>Solidago juncea</i> — <i>Scleria triglomerata</i> — <i>Rudbeckia serotina</i> — <i>Aster azureus</i> (Maycock & Langendoen-6031-1982). Dry-mesic upland tallgrass prairie — sand — <i>Aster laevis</i> — <i>Solidago juncea</i> — <i>Poa compressa</i> — <i>Coreopsis tripteris</i> — <i>Aster ericoides</i> (Maycock & Pratt-6039-1975). Dry-mesic upland tallgrass prairie — sand — <i>Solidago juncea</i> — <i>Aster laevis</i> — <i>Poa compressa</i> — <i>Euphorbia corollata</i> — <i>Aster ericoides</i> — <i>Coreopsis tripteris</i> (Langendoen-6039-1982). Mesic upland tallgrass prairie — sand — <i>Coreopsis tripteris</i> — <i>Aster ericoides</i> — <i>Poa compressa</i> — <i>Solidago canadensis</i> — <i>S. juncea</i> (Maycock-6032-1973). Mesic upland tallgrass prairie — sand — <i>Lespedeza capitata</i> — <i>Solidago gigantea</i> — <i>Poa compressa</i> — <i>Solidago canadensis</i> — <i>Aster ericoides</i> (Maycock-6041-1975). Mesic upland tallgrass prairie — sand — <i>Solidago rigida</i> — <i>Poa compressa</i> — <i>Aster ericoides</i> — <i>Monarda fistulosa</i> — <i>Panicum lanuginosum</i> (Maycock-6045-1975). Mesic upland tallgrass prairie — sand — <i>Solidago rigida</i> — <i>Liatris spicata</i> — <i>Aronia melanocarpa</i> — <i>Scleria triglomerata</i> — <i>Coreopsis tripteris</i> — <i>Euphorbia corollata</i> — <i>Solidago canadensis</i> (Langendoen-6064-1981). Mesic upland tallgrass prairie — sand — <i>Solidago juncea</i> — <i>S. canadensis</i> — <i>Liatris spicata</i> — <i>Coreopsis tripteris</i> — <i>Andropogon gerardi</i> (Langendoen-6065-1982). Mesic upland tallgrass prairie — sand — <i>Sorghastrum nutans</i> — <i>Solidago juncea</i> — <i>Aster azureus</i> — <i>Pycnanthemum virginianum</i> — <i>Solidago altissima</i> — <i>Rubus flagellaris</i> (Langendoen-6074-1982). Mesic upland tallgrass prairie — sand — <i>Panicum virgatum</i> — <i>Desmodium canadensis</i> — <i>Sporobolus asper</i> — <i>Pycnanthemum virginianum</i> — <i>Solidago graminifolia</i> — <i>S. canadensis</i> (Langendoen-6076-1982). Wet-mesic tallgrass prairie — sand — <i>Andropogon gerardi</i> — <i>Aster umbellatus</i> — <i>Desmodium canadense</i> — <i>Pycnanthemum virginianum</i> — <i>Apios americana</i> (Langendoen-6063-1982). Wet-mesic tallgrass prairie — sand — <i>Spartina pectinata</i> — <i>Panicum virgatum</i> — <i>Solidago canadensis</i> — <i>Coreopsis tripteris</i> — <i>Solidago rigida</i> (Maycock & Hills-6016-1969).

(continued)

TABLE I. Continued

Location	Vegetation
41. (Continued)	Wet mesic tallgrass prairie — sand — <i>Spartina pectinata</i> — <i>Calamagrostis canadensis</i> — <i>Desmodium canadense</i> — <i>Pycnanthemum virginianum</i> — <i>Veronicastrum virginianum</i> (Maycock & Ball-6017-1971).
	Wet mesic tallgrass prairie — sand — <i>Calamagrostis canadensis</i> — <i>Solidago canadensis</i> — <i>Rubus flagellaris</i> — <i>Pycnanthemum virginianum</i> — <i>Spartina pectinata</i> (Langendoen-6017-1982).
	Wet mesic tallgrass prairie — sand — <i>Spartina pectinata</i> — <i>Pycnanthemum virginianum</i> — <i>Solidago canadensis</i> — <i>S. graminifolia</i> — <i>Aster ericoides</i> (Langendoen-6021-1982).
	Wet mesic tallgrass prairie — sand — <i>Andropogon gerardi</i> — <i>Spiraea tomentosa</i> — <i>Spartina pectinata</i> — <i>Onoclea sensibilis</i> — <i>Apios americana</i> (Langendoen-6040-1982).
	Wet mesic tallgrass prairie — sand — <i>Andropogon gerardi</i> — <i>Spartina pectinata</i> — <i>Pycnanthemum virginianum</i> — <i>Carex lasiocarpa</i> — <i>Muhlenbergia frondosa</i> (Maycock & Pratt-6042-1975).
	Wet mesic tallgrass prairie — sand — <i>Spartina pectinata</i> — <i>Solidago canadensis</i> — <i>Calamagrostis canadensis</i> — <i>Veronicastrum virginianum</i> — <i>Pycnanthemum virginianum</i> (Langendoen-6044-1982).
	Wet lowland tallgrass prairie — sand — <i>Calamagrostis canadensis</i> — <i>Spartina pectinata</i> — <i>Aster umbellatus</i> — <i>Osmunda regalis</i> — <i>Dryopteris thelypteris</i> (Maycock & Ball-6019-1971).
	Wet lowland tallgrass prairie — sand — <i>Calamagrostis canadensis</i> — <i>Spartina pectinata</i> — <i>Aster umbellatus</i> — <i>Pycnanthemum virginianum</i> — <i>Solidago graminifolia</i> (Langendoen-6019-1982).
	Wet lowland tallgrass prairie — sand — <i>Calamagrostis canadensis</i> — <i>Spartina pectinata</i> — <i>Solidago canadensis</i> — <i>S. rugosa</i> — <i>Pycnanthemum virginianum</i> (Maycock & Pratt-6044-1975).
	Wet lowland tallgrass prairie — sand — <i>Spartina pectinata</i> — <i>Andropogon gerardi</i> — <i>Calamagrostis canadensis</i> — <i>Panicum virgatum</i> — <i>Carex lanuginosa</i> (Maycock & Pratt-6046-1975).
42. Fair Play, Maidstone Township (42° 13'N, 82° 51'W)	Wet mesic lowland deciduous forest — clay — <i>Ulmus americana</i> — <i>Acer rubrum</i> — <i>A. saccharinum</i> / <i>Tilia americana</i> — <i>Quercus macrocarpa</i> — <i>Q. rubra</i> — <i>Fraxinus americana</i> — <i>Carya ovata</i> — <i>Fraxinus nigra</i> — <i>Fagus grandifolia</i> — <i>Ostrya virginiana</i> — <i>Acer saccharum</i> — <i>Carpinus caroliniana</i> — <i>Carya cordiformis</i> (Maycock-58-1958).
43. Emeryville Clay Plain, Maidstone Township (42° 15'N, 82° 47'W)	Wet lowland deciduous forest — clay — <i>Quercus bicolor</i> — <i>Fraxinus pennsylvanica</i> — <i>Quercus palustris</i> / <i>Tilia americana</i> — <i>Fagus grandifolia</i> — <i>Quercus macrocarpa</i> (Walshe-IBP-1970).
44. Ruscom, Rochester Township (42° 12'N, 82° 42'W)	Wet lowland deciduous forest — clay — <i>Ulmus americana</i> — <i>Fraxinus americana</i> — <i>Quercus macrocarpa</i> — <i>Acer saccharinum</i> / <i>Tilia americana</i> — <i>Carya ovata</i> — <i>Fraxinus nigra</i> — <i>F. pennsylvanica</i> — <i>Quercus bicolor</i> — <i>Q. palustris</i> — <i>Q. rubra</i> — <i>Populus deltoides</i> — <i>Carya cordiformis</i> — <i>Carpinus caroliniana</i> (Maycock-76-1959).
45. Ruscom Shores, Rochester Township (42° 18'N, 82° 37'W)	Wet lowland deciduous forest — sand — <i>Juglans nigra</i> — <i>Fraxinus pennsylvanica</i> — <i>Quercus rubra</i> — <i>Q. bicolor</i> (Oldham-ER-1983) Saturated marsh — sand — <i>Typha latifolia</i> (Oldham-ER-1983).

of ecological importance as determined by the Point Quarter Method (Maycock 1963) for forests or in randomly distributed m² quadrats for other vegetational communities. In the International Biological Program studies dominants were determined by a visual estimate of the various major elements of the community. Dominance was also estimated in most other reports and it is important to realize that studies of varying intensity have been used to assess significance both with respect to different stands and

different workers. In some cases available data are scant while in others there is much detailed information on file about the community. There is often considerable environmental assessment or measurement including topography, soils, microclimate, etc., and specific compositional data including comprehensive presence lists and frequency and cover data for individual species. There may also be historical information such as information on perturbations, succession, fire or logging and human intervention.

In the forest descriptions more tree dominants usually are included than are required to identify the community. Major dominant species clearly identify the community and generally account for two thirds of total stand importance. When this information is available these species are separated within the sequence of dominants by an oblique stroke. Inclusion of species in addition to major dominants provides an indication of the great compositional variability from site to site.

In many instances the listing includes less common as well as rare and ecologically or phytogeographically interesting species. Certainly with respect to tree species, the rich compositional variety of southern forests is included. Although there are frequently unusual rare or endangered understorey plants associated in the stands and sites, no attempt is made to present all occurrences. Such information is usually on record and could be made available. The community approach ensures that there are viable populations of both representative and rare species among the recognized sites. Some sites are representative of a widespread Ontario ecosystem; others may include uncommon communities such as dunes, marshes, meadows, carrs, or prairies. Many listed areas are large diverse complexes which include a number of communities or ecosystems; others are more homogeneous and smaller and include only one community.

Discussion

The individual reasons for listing each site and the relative merits of each is beyond the scope of this paper. Within Essex county where there is minimal natural vegetation remaining, any sizeable plant community or area of vegetation, either representative or unusual, is important. Many sites are of additional interest because the vegetation has been specifically documented, often quantitatively, and can serve as a reference for future comparisons. Several of the sites support vegetational communities which are highly unusual in both Ontario and Canada and which are responding to unusual or uncommon ecological conditions, while others are viable natural representative samples of vegetation which previously occurred over vast tracts in this part of Ontario. Many communities which are included harbour uncommon, ecologically interesting, rare or endangered plants and animals. In these cases a full account of such species is available from the reference sources. Although the occurrence of rare or endangered species was not the basis for this list, such a compilation is of value and would include many of the vegetational sites in the present paper. The national significance of the flora and vegetation still remaining in this region cannot be overemphasized.

It is evident that much more information is available for some localities than others. This is the result of more intensive studies there for specific contract projects. An example is the abundant data for Point Pelee National Park gathered by PFM for Parks Canada on several occasions (Maycock 1972*, 1977*) and on the Objibway Prairie where extensive studies were undertaken in the early 1970s as part of an effort to have this magnificent prairie-savanna complex preserved (Maycock 1971*; Maycock and Hills 1970*; Pratt 1979*).

The Ojibway Prairie complex is now protected and is managed by the Ontario Ministry of Natural Resources. A number of other sites listed have enjoyed park status for many years and in most cases have been afforded a degree of protection. Point Pelee National Park, for example, encompasses a diverse and complex vegetational mosaic which includes the many different Pelee communities inventoried here. Two sites on Pelee Island have recently been protected through regulation as Nature Reserve Provincial Parks, and another, The Stone Road prairie-savanna and alvar complex, was recently conserved by the Federation of Ontario Naturalists. The Cedar Creek site and the Hillman Marsh were both purchased in 1984 with the assistance of the Nature Conservancy of Canada.

However, even if all sites listed were set aside they would represent only a small percentage of the total land area of Essex county. Currently less than 0.01% is designated strictly as nature reserves. Even if Conservation Areas and other multiple use areas were considered to be "protected" the total would not be adequate. A recommended level of dedicated lands is in the order of 20% of the total (Helliwell 1975), but this level has certainly not been remotely approached anywhere in southern Ontario.

Two of the vegetationally significant sites which are shown in Table 1 in bold face (see sites 19 and 41) have been destroyed already, and others may have been lost as well. Field reconnaissance would be necessary to ascertain the condition of many of the sites at the present time.

The inventory presented here does not include all significant vegetation in Essex County. For example, P. F. Catling and A. A. Reznicek (personal communications) indicate that critically important sites occur on the northern end of Fighting Island in Sandwich West Township. One is a dry *Quercus velutina* forest, another a wet-mesic *Q. macrocarpa* site and a third, a tall grass prairie including *Andropogon gerardi* and *Coreopsis tripteris*. However, neither a quantitative vegetational study nor a presence list is available, so these communities are not included here. Other important locations will likely be found through

closer examination of forested areas shown on the Resource Inventory maps.

While new sites may be added in the future as they are discovered and documented, the present list has been widely reviewed and probably represents the best approximation to date of ecologically significant vegetational communities in Essex County.

Acknowledgments

We thank G. W. Argus, V. Harms and G. F. Ledingham, all members of the Canadian Botanical Association Conservation Committee, for their constructive suggestions and comments, and we acknowledge as well valued input from the following experts: P. Keddy, P. Catling, J. Webber, P. W. Ball, W. R. Crins, S. Varga, A. A. Reznicek, J. H. Soper, J. Morton, M. Oldham, and R. Klinkenberg. Ball, Reznicek, Crins and Webber also assisted P. F. M. on many occasions in making difficult taxonomic determinations. T. Beechey of the Park Planning Branch, Ministry of Natural Resources, supplied literature in addition to valuable counsel, and the work of various other personnel of the Ministry of Natural Resources, Park Planning Branch who inventoried many areas is gratefully acknowledged.

Source Documents

These are referenced in text by author and date followed by an asterisk to distinguish them from publications (see Literature Cited).

The following are available in the Heritage Resource Library, Parks Planning, Parks Branch, Ministry of Natural Resources, Queen's Park, Toronto, Ontario M7A 1W3, and in the Regional Office of the Ministry of Natural Resources, Box 5463, London, Ontario N6A 4L6.

- Campbell, C. A.** 1971. Preliminary Pelee Island Inventory. Nature Reserves Parks Branch, Ontario Department of Lands and Forests, Toronto.
- Campbell, C. A.** 1976. Ecological report on Lighthouse Point, Fish Point and East Sister Island Nature Reserves, Essex Co., Ontario. Ontario Ministry of Natural Resources, Chatham.
- Hills, G. A.** 1959. A ready reference to the description of land in Ontario and its productivity. Preliminary report. Ontario Department of Lands and Forests, Maple.
- Hills, G. A.** 1961. The ecological basis for land-use planning. Research Report No. 46. Ontario Department of Lands and Forests, Toronto.
- Hills, S. G., and T. C. Moull.** 1985. Landowner contact pilot project final report: 1984. Ontario Heritage Foundation, Ontario Ministry of Citizenship and Culture.

- International Biological Program.** 1970. Check sheets for Essex County. Natural Resources Library. Ontario Ministry of Natural Resources. Whitney Block, Room 4540, 99 Wellesley St. W., Toronto, Ontario. M7A 1W3.
- Klinkenberg, R.** 1982. A reconnaissance life science inventory of Holiday Beach Provincial Park and adjacent Waterfowl Management Unit. Ontario Ministry of Natural Resources, Southwestern Region.
- Klinkenberg, R.** 1985. Life science areas of natural and scientific interest in Site District 7-1. Open File Ecological Report 8402. Parks and Recreation Areas, Ministry of Natural Resources, Southwestern Region, London.
- Macdonald, I., and T. Beechey.** 1970. Inventory of Tremblay Beach Provincial Park. Open File Ecological Report 7015. Provincial Parks, Ontario Department of Lands and Forests, Toronto.
- Maycock, P. F.** 1971. The Ojibway Prairie near Windsor, Ontario. Report to the Ontario Panel of International Biological Program and the Nature Conservancy of Canada.
- Maycock, P. F., and A. Hills.** 1970. The Ojibway Prairie Tract, Essex County, Ontario.
- Oldham, M. J.** 1983. Environmentally significant areas of the Essex Region. Essex Region Conservation Authority, Essex, Ontario.
- Pratt, P. D.** 1979. A preliminary life science inventory of the Ojibway prairie complex and surrounding area. Ontario Ministry of Natural Resources, Chatham, Ontario.

The following are available in Parks Canada collections at Point Pelee National Park, R.R.1, Leamington, Ontario N8H 3V4.

- Maycock, P. F.** 1972. An ecological study of the forests of Point Pelee, Essex County, Ontario. Report to the National and Historic Parks Branch, Department of Indian Affairs and Northern Development, Ottawa.
- Maycock, P. F.** 1977. A floristic and ecological survey of the terrestrial vegetation of Point Pelee National Park. Report to the National and Historic Parks Branch, Department of Indian Affairs and Northern Development, Ottawa.

Literature Cited

- Fernald, M. L.** 1950. Gray's Manual of Botany. American Book Company, New York.
- Helliwell, D. R.** 1975. The concept of waste and the conservation of nature. *Environmental Conservation* 2: 271-273.
- Maycock, P. F.** 1963. The phytosociology of the deciduous forests of extreme southern Ontario. *Canadian Journal of Botany*. 41: 380-438.

Received 11 October 1985

Accepted 25 August 1986

Minutes of the 108th Annual Business Meeting of The Ottawa Field-Naturalists' Club: 13 January 1987

Place and Time:

Auditorium, Victoria Memorial Museum Building,
Metcalfe and McLeod Streets, Ottawa. 2007 hrs.

Chairman: Mr. W.K. Gummer, President

Attendance: About 55 people attended the meeting.

1. Minutes of the Previous Meeting

E. Bottomley, Recording Secretary, read the minutes of the 107th Annual Business Meeting.* It was moved by E. Dickson (2nd R. Taylor) that the minutes be approved.

(Motion Carried)

2. Business Arising from the Minutes

The President noted the sad loss of Club member Frank Bell, and informed the meeting that the Karstad painting raffle had raised approximately \$1400 which went into the Alfred Bog Fund.

3. Finance

The Chairman of the Finance Committee, F. Pope (for P. Ward, Treasurer), presented the financial statements. He explained that the team that deals with the Club's money consists of Paul Ward, who prepares the financial statement and the budget, Lois Cody, who collects the mail, posts the ledger and issues receipts, and Bill Cody, who writes cheques and manages funds.

F. Pope pointed out that the Members Equity for 1986, while in a sound position at \$71,009, was \$3,101 less than in 1985. The challenge is for the 1987 Council to control costs. Membership dues have been unchanged for 1984-87, and an increase for 1988 may be necessary. Increased printing costs and postage charges for *The Canadian Field-Naturalist* have contributed to the decrease in the Members Equity. F. Pope noted that donations appear under Members Equity rather than as income.

In 1986, the Club purchased a microcomputer for \$4,400 which is shown under Assets (Less: Accumulated Depreciation). The Carp Hills Fund was cleared with a refund of \$6,663 to the City of Ottawa.

The Ottawa Field-Naturalists' Club Balance Sheet as of 30 September 1986

	ASSETS	
	1986	1985
CURRENT		
Cash and Term Deposits	\$ 90 864	\$106 120
Accounts Receivable	22 981	15 228
Accrued Interest	120	350
Prepaid Expenses	1 105	1 105
	<u>115 070</u>	<u>122 803</u>
FIXED		
Equipment:		
Less Accumulated Depreciation	3 892	918
Land: Alfred Bog	3 348	3 152
	<u>7 240</u>	<u>4 070</u>
	<u>\$122 310</u>	<u>\$126 873</u>
LIABILITIES, FUNDS AND MEMBERS EQUITY		
CURRENT LIABILITIES		
Accounts Payable	\$ 26 280	\$ 15 917
Deferred Income	10 485	10 487
	<u>36 765</u>	<u>26 404</u>
MEMORIAL FUNDS		
Anne Hanes	790	780
Baldwin	258	213
	<u>1 048</u>	<u>993</u>
OTHER FUNDS		
Carp Hills	—	12 674
Alfred Bog Protection	7 482	6 946
Seedathon	406	846
Bird Atlas Grant	—	500
	<u>7 888</u>	<u>20 966</u>
LIFE MEMBERSHIPS	5 600	4 400
MEMBERS EQUITY		
Balance 1 October 1985	74 110	62 114
Donations	1 633	2 000
Income over Expenditure for Year The Ottawa Field-Naturalists' Club	1 939	1 505
<i>The Canadian Field-Naturalist</i>	(6 717)	7 108
Centennial Projects	44	1 383
	<u>71 009</u>	<u>74 110</u>
TOTAL LIABILITIES, FUNDS AND MEMBERS EQUITY	<u>\$122 310</u>	<u>\$126 873</u>

*See *The Canadian Field-Naturalist* 100(3): 427-434.

**Statement of Income and Expenditure
The Ottawa Field-Naturalist Club
for the year ended 30 September 1986**

	1986	1985
INCOME		
Apportionment of Membership Fees		
Annual	\$12 344	\$12 451
<i>Trail and Landscape</i>		
Subscriptions	425	391
Back Numbers	169	447
	594	838
<i>Shrike</i> Subscription	15	907
	12 953	14 196
Interest	1 781	1 806
Total	14 734	16 002
EXPENDITURE		
<i>Trail & Landscape</i>		
Printing	4 530	5 744
Circulation	285	301
Production	1 051	348
Honoraria	605	550
	6 471	6 943
<i>Shrike</i> Publishing	88	706
Committee Activities — Net		
Excursions and Lectures	(1 702)	(426)
Membership	1 290	1 055
Macoun Club	363	335
Conservation	57	110
Birds	455	1 075
Special Publication	987	Nil
Affiliation Fees	325	326
Baldwin Scholarship	150	150
Office Assistant	471	439
Office Supplies and Expenses	3 825	1 950
Computer Charges	—	1 114
Miscellaneous	15	720
	6 236	6 848
Total	12 795	14 497

**EXCESS OF INCOME OVER
EXPENDITURE** \$ 1 939 \$ 1 505

**Statement of Income and Expenditure
The Canadian Field-Naturalist
for the year ended 30 September 1986**

	1986	1985
INCOME		
Apportionment of Membership Fees		
Annual	\$ 8 229	\$ 8 300
Subscriptions	22 091	21 694
	30 320	29 994
Publication		
Reprints	6 447	8 867
Plates and Tab Settings	3 699	3 360
Extra Pages	14 303	22 903
Back Numbers	1 016	751
	25 465	35 881
Other		
Interest	7 122	7 424
Exchange	2 543	2 124
	9 665	9 548
Total	65 450	75 423

EXPENDITURE		
Publishing	52 700	48 201
Reprints	5 223	6 906
Circulation	7 130	5 680
Editing	1 701	2 000
Office Assistant	3 051	2 862
Office Supplies	388	786
Honoraria	1 974	1 880
	72 167	68 315

**EXCESS OF INCOME OVER
EXPENDITURE** \$ (6 717) \$ 7 108

**Notes to the Financial Statements
Year Ended 30 September 1986**

1. Authority and Activities

The Ottawa Field-Naturalists' Club is a non-profit organization incorporated under the laws of the Province of Ontario (1884). The Ottawa Field-Naturalists' Club promotes the appreciation, preservation and conservation of Canada's natural heritage; encourages investigation and publishes the results of research in all fields of natural history and diffuses information on these fields as widely as possible. It also supports and cooperates with organizations engaged in preserving, maintaining or restoring environments of high quality for living things. Membership is open to any person or family, upon application and payment of dues. Payment of the Annual Dues as set out in the By-laws will be a necessary condition for the continuance of Membership.

2. Significant Accounting Policies

Memberships, subscriptions and donations are recorded as received. All other revenues and expenditures are recorded on the accrual basis.

*As published, these reports contain revisions made at the January 1987 Meeting of Council.

3. Life Memberships

Life memberships paid since 1977 are recorded at the fee in effect at that time. There are 37 life members.

4. Comparative Figures

Certain figures for 1985 presented for comparison purposes have been reclassified to conform to the 1986 presentation.

Auditor's Report

I have examined the balance sheet of The Ottawa Field-Naturalists' Club as at 30 September 1986 and the statements of operations for the year ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Corporation as at 30 September 1986 and the results of its operations for the year then ended in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

F. MONTGOMERY BRIGHAM, C.A.

Ottawa, Canada
22 December 1986

The following comments were made:

- a) There were three new Life Memberships paid by 30 September 1986; a fourth Life Membership was received after this date in 1986.
- b) A donation of \$100 to the Anne Hanes Memorial Fund was received after 1 October 1986, so it is not shown on the Balance Sheet.
- b) A residual income continues to the Centennial Projects.

F. Pope moved (2nd W. Cody) to accept the financial statement.

(Motion Carried)

4. Report of Council

This report consists of reports by Committees of the Council. The President prefaced the report by noting that four Committee reports (Birds, Conservation, Education and Publicity, and Macoun Club) were submitted late so had not yet been formally reviewed by Council. As a result, slight changes might be made to the content of these late reports upon review at the January 1987 Council meeting.*

Awards Committee

Daniel F. Brunton (Chairman)	Peter Hall
E. Frankton	Dianna Laubitz
W. K. Gummer	Mary Stuart

The Committee met several times during 1986 to conduct committee business.

There were 22 awards nominations received by the Committee, down somewhat from previous years. An OFNC Awards Nominations form was prepared and was circulated

amongst the members of Council and at a Club monthly meeting in order to generate more nominations for the 1986 awards year. As well as considering OFNC awards, nominations of Club members for several outside awards (such as the Governor General's Conservation Award) were prepared by the Awards Committee and are still in process. We also recommended to the Federation of Ontario Naturalists that they establish a provincial "Naturalist of the Year" award and advised them on possible selection criteria for such a tribute.

The Awards Committee recommended the following individuals for OFNC awards:

- | | |
|-------------------------------------|--|
| — Honorary Member: | Claude Garton
Thunder Bay, Ontario
Edward Bousfield
Ottawa, Ontario |
| — Member of the Year: | Ellaine Dickson
Ottawa, Ontario |
| — Conservation Award: | James Richards
Oshawa, Ontario |
| — Anne Hanes Natural History Award: | Ross Anderson
Ottawa, Ontario |

These were accepted by Council and were announced at the 1986 Soirée, where presentations were made to several of the recipients. Citations accompanying the awards will appear in a forthcoming issue of *The Canadian Field-Naturalist*.

A new OFNC prize, the President's Prize, was established this year. It actually was first offered in the early years of the Club more than a century ago but the practice had lapsed. It is awarded by the OFNC President "... to the Club member who in the President's opinion stands out for effort, accomplishment, or activity, not covered by the official awards of the Club." The first award was made by 1985 President Frank Pope to Christine Hanrahan of Ottawa.

In addition to these OFNC tributes, Donald Cuddy of Kemptville, Ontario was awarded a Conservation Achievement Certificate by the Federation of Ontario Naturalists, upon our recommendation.

Club members were saddened in 1986 by the death of Frank H. Bell, our 1985 Member of the Year Award recipient. A tribute to this well-liked and hard-working member can be found in *Trail & Landscape* 20(5): 195-196 (1986).

(D.F. Brunton)

Birds Committee

V. Bernard Ladouceur (Chairman)	Christine Hanrahan
Roy John (Vice-chairman)	Jeff Harrison (Ex-officio)
C. Wright Smith (Secretary)	Daniel Perrier
Tony Beck	Gordon Pringle
Frank Bell	Joyce Reddoch
Margaret Benson	Chris Rimmer
Robert A. Bracken	John Sankey
Allan Cameron	Art Thompson
(OFNC Council liaison)	Daniel Toussaint
Michelle Elder	(Club des ornithologues de l'Outaouais liaison)
(Finance position)	Mark Gawn

In 1986, the Birds Committee formulated and approved a formal terms of reference for the first time since its inception in 1980. Until this time the Committee had been using tradition and the original proposal of J. D. Lafontaine and D. F. Brunton (separating what was known as the Rare Birds Committee into the Birds Committee and the Bird Records Subcommittee) to set its agenda.

The Birds Committee also created a new office, a finance position, to be given a formal name by OFNC Council later. The Committee will bring a budget proposal to Council and the new officer will keep record of Committee spending, as well as informing the Committee on the status of the Seedathon fund.

SUBCOMMITTEES

Bird Records

Roy John (Chairman)	Mark Gawn
Gordon Pringle	Robert Gorman
(Secretary, non-voting)	(Alternate)
Robert A. Bracken	Jim Harris (Alternate)
F. Montgomery Brighan	V. Bernard Ladouceur
Bruce M. Di Labio	Michael Runtz

It was a year of self examination for the Bird Records Subcommittee and it resulted in the Subcommittee adopting some changes including: a) a more formal setting for meetings, and b) a new formula to ensure significant rotation in membership. The latter (b) was incorporated into a terms of reference drawn up for Council by the Bird Records Subcommittee and approved by the Birds Committee. In addition to staying current in reviewing rare bird reports and re-assessing some old reports, the Bird Records Subcommittee produced a new daily bird checklist ("The Ottawa District Daily Bird Field List"). This was financed by the Seedathon fund.

Bird Feeders

Daniel Perrier (Chairman)

Feeder

Jack Pine Trail
Pink Road¹

Davidson Road
Mer Bleue
Rockliffe Park
Stony Swamp

Operators

Roy Millen
Daniel Toussaint
M. Lavasseur
George McGee & Friends
Daniel & Jean Perrier
Daniel & Jean Perrier
Roy Millen

(seed supplied by the
National Capital
Commission)

¹In co-operation with the Club des ornithologues de l'Outaouais.

Seed was purchased for an excellent price of \$12 per 50 lb bag. It appears that the Kanata feeder will not operate for the 1986-87 season because of problems with vandalism.

Ad Hoc Bird Publication

Mark Gawn (Chairman)	V. Bernard Ladouceur
Bruce M. Di Labio	Joyce Reddoch
Stephen Gawn	

This Subcommittee was struck after publication of *The Shrike* was suspended. It immediately went about the

business of completing issues of *The Shrike* that had been left unedited and unpublished since 1985.

Next year the Subcommittee will oversee the production of an annual report to be published in *Trail & Landscape*.

OTHER BIRDS COMMITTEE BUSINESS

Bird Status Line: The operation of the OFNC Bird Status Line was interrupted for several months in 1986 but the problem was solved when Larry Neily volunteered his services and Roy John and Tony Beck agreed to be backups. The Birds Committee also produced guidelines for the operation of the Bird Status Line. The new number is 225-4333 and will be listed in the telephone directory under The Ottawa Field-Naturalists' Club.

Christmas Bird Census: Allan Cameron was the compiler of the Ottawa-Hull Christmas Bird Count held December 21. Over one hundred field observers plus feeder watchers took part. The fee controversy subsided somewhat as the National Audubon Society agreed to accept \$3 Canadian (instead of \$3 U.S.) per participant. Our thanks to Allan for running a very smooth count.

Spring and Fall Bird Counts: Spring and Fall Bird Counts were held again after being missed the previous year. Bruce Di Labio compiled both counts which were held 18 May and 31 August, respectively. It appears that the Birds Committee wishes these activities to continue on an annual basis as they have been included in its terms of reference.

OFNC Seedathon: The sixth annual OFNC Seedathon was held September 7th. Two parties took part and over \$1,300 was raised. Special thanks to Bruce Di Labio who, again, was responsible for finding most of the sponsors.

Death of Frank Bell: The Birds Committee lost one of its hardest working members in 1986. Frank Bell had been a member of the Committee since it began in 1980. The Birds Committee expressed its sympathies to the Bell family by sending flowers.

New Chairman for 1987: After three years as Chairman, V. B. Ladouceur has decided to step down, and would like to thank everyone who helped in performing Birds Committee duties while he was Chairman. The new Chairman is wished success in 1987.

(V. B. Ladouceur)

Conservation Committee

Lynda Maltby (Chairman)	Robert Milko
Caroline Harris (Secretary)	Joyce Reddoch
Suzanne Blain	Ena Spalding
Eleanor Bottomley	Kim Taylor
Tom Clark	Roger Taylor
Fern Levine	Ewen Todd
Barbara Martin	Jane Topping
Philip Martin	

The Conservation Committee has been very active on a number of fronts, nationally, provincially and locally. The Committee has 15 active members and we are especially thankful for all the work done by Caroline Harris who religiously typed and distributed all the minutes. The following is a list of major issues that the Committee has been involved in during 1986.

National —

a) South Moresby: Conservation Committee was actively involved in the promotion of South Moresby being afforded some kind of protection so that it may be retained in its natural state. Members also participated on the South Moresby Caravan and gave full support to the Canadian Nature Federation for their efforts.

b) North American Waterfowl Management Plan: Comments and input were provided to Environment Canada by the Conservation Committee supporting the objectives of the plan.

c) Wildlife '87: The Conservation Committee supports the objectives of Wildlife '87 and has as its special project, Alfred Bog.

d) Excise Tax: B. Turner, M.P., distributed material for his excise tax scheme. There was general support for the concept of raising monies to be spent on wildlife conservation projects; however, the mechanism is in debate. Comments are being drafted.

Provincial —

a) Alfred Bog is top of the list and much effort has been put toward arranging to have some form of protection for the bog. A steering committee consisting of various provincial and non-government representatives was put in place to oversee the much needed work that is to take place. Currently, a management plan for the bog is being developed.

A raffle of a painting of Alfred Bog, donated by Aleta Karstad, took place and approximately \$1400 was raised.

b) Wetlands: A wetlands awareness campaign was initiated by the Federation of Ontario Naturalists. The Conservation Committee has a wetlands subcommittee in place to deal with issues related to wetlands.

c) Marlborough Forest: A member of the Conservation Committee sits on the Regional Planning Advisory Committee. The Conservation Committee has provided input and suggestions to the management plans developed for this area. Field checks have also taken place to obtain further information in the area.

d) Pesticide Spraying: OFNC Conservation Committee supported other groups to prevent the spraying of pesticides for gypsy moth control. The province opted for using only a biological agent, *Bacillus thuringiensis* (Bt), which was supported by the Committee.

e) Snared Eagles: Concern was voiced by the Conservation Committee on recommended Ontario Ministry of Natural Resources (OMNR) trapping methods that allowed the snaring of a golden and bald eagle in a four week period. The Committee recommended different trapping methods that would prevent this thing from happening. A letter voicing our concerns was sent to OMNR.

Local —

a) Regional Municipality of Ottawa-Carleton (RMOC) Waste Management Plan: The Conservation Committee has an active member in the RMOC Waste management Task Force. Many public hearings and briefs were presented by members of the Committee and one brief encouraging recycling of garbage and avoidance of natural areas for dump or transfer sites was written on behalf of the Club.

b) National Capital Commission (NCC) Land Management Plan: Members of the Committee reviewed the Land Management Plan prepared by the NCC and also attended a presentation by the NCC. The OFNC provided comments to the NCC basically stressing the importance of Greenbelt Areas in the district for wildlife and also suggesting the consideration of other areas for protection such as wetlands along the Ottawa River.

c) Environmental Non-government Organization (ENGO) Network: Conservation Committee is involved in supporting the efforts of ENGOs and has a representative participating in their meetings.

Many more issues are taken care of but are too numerous to mention. If you are interested in conservation and wish to participate, please feel free to contact us. The Chairman, L. Maltby, thanks all members of the Committee who volunteered their time to make things happen.

(L. S. Maltby)

Education and Publicity Committee

Betty Marwood (Chairman)	Bill Teager
Linda Capel	Dianna Thompson
Jeff Harrison	Susanna Wood
Bill Knight	Dorothy Zarski
Ken Taylor	

During 1986 six meetings were held. We were able to: a) identify within the Club mandate this Committee's programme and activities, and b) improve the resources available through the Committee by creating a roster of volunteers to assist with activities.

One of the most important accomplishments this year was to get individuals from the membership at large involved in Club activities developed by this Committee. Twenty people volunteered for the National Capital Commission's Fall Rhapsody — a major commitment of time and skills for a programme covering weekends from September 20 to October 13. Twenty-three people participated in the OFNC display at the Ottawa Duck Club Nature Art Show, a three day event.

The Club exhibit was examined and plans are underway for its redevelopment early in 1987. This exhibit was also used at the New Members Night, and the Clubs Day at the National Museum of Natural Sciences.

Judges and awards were provided at the Regional Science Fair. The Committee provided speakers or leaders for the following:

January — slide show and outing to the Jack Pine Bird Feeder for residents of Unitarian House

February — nature walk for Beaver Pack

April — talk to another Beaver Pack on making bird feeders

May — about 70 Girl Guide leaders, bird-watching tour

June — talk to Rideau Valley Naturalists on "Bird Feeders and Planting for Wildlife"

November — slide show on birds for Beacon Hill Lodge residents.

One request was refused in November because only one day of notice was given. Otherwise, the Committee was able to fulfill all requests for speakers or leaders. Club members who give freely of their time for this service should be commended.

(B. M. Marwood)

Excursions and Lectures Committee

Ross Anderson (Chairman)	Ellaine Dickson
Robina Bennett	Eileen Evans
Allan Cameron	Colin Gaskell
Barbara Campbell	Rick Leavens
Rick Killeen	Philip Martin

The Excursions and Lectures Committee held bi-monthly meetings in 1986 together with numerous meetings of groups responsible for tours and special projects.

Activities promoted by the Committee for the participation and enjoyment of all members were as follows:

Excursions	32
Day Trips	13
Tours and Overnight Trips	4
Lectures and Special Events	13

In general excursions take place in the Ottawa-Hull area and occupy an evening or half a day. Day trips extend to sites outside our immediate area and are arranged to occupy a full day, morning to night. Tours include overnight trips and extend to such elaborate, extended and well planned events as the Gaspé trip which occupied eight days and required a budget exceeding \$15 000.00.

Lectures and special events included a successful series of monthly meetings, the Annual Soirée and members' slide night. Six distinguished speakers were guests of the Ottawa Field-Naturalists' Club during the course of the year. The monthly meetings, held at the National Museum of Natural Sciences and open to the general public, including refreshments, were attended by an estimated average of 40 to 60 persons.

The Committee will welcome suggestions by interested members of the Club for projects in 1987. Excursion leaders willing to develop and carry out any project of particular interest to other Club members and to other community groups on behalf of the Club are cordially invited to contact the Chairman or any member of the Committee.

Cordial thanks to members of the Committee who have often done the Chairman's work as well as their own, and to all the volunteers who make excursions and lectures such an important part of Club activities.

(R. Anderson)

Finance Committee

Frank Pope (Chairman)	Charles Gruchy
Ronald Bedford	Jeff Harrison
Daniel F. Branton	C. Rounding
William Cody	Paul Ward
Fran Goodspeed	

The Committee met three times during the year. Recommendations were made to Council concerning the following matters: a) investment in a new supply of tape cassettes for Songs of the Seasons; b) expenditure on illustrations for a proposed special publication; c) some minor changes in the presentation of the financial statements, and d) an investment and banking strategy for Club funds. Record keeping practices that are compatible with official Club records were recommended to committees desiring to monitor expenses. The Committee was consulted on the financial aspects of acquiring a microcomputer, life memberships, insurance and managing the Alfred Bog Fund.

(F. Pope)

Macoun Club Committee

Don Fillman (Chairman)	Connie Downes
Fenja Brodo	Paul Hamilton
Martha Camfield	Robert Lee
Barbara Campbell	Vic Solman
Robin Collins	

Robin Collins stepped down as Co-ordinator of the Macoun Field Club (MFC) after two years of service to the Club. The MFC thanks Robin for the time and effort spent to ensure that the Club activities operated smoothly. Paul Hamilton is the new Co-ordinator for the 1986-87 school year.

This year new terms of reference were outlined by the OFNC and the National Museum of Natural Sciences (NMNS), both being sponsors of the MFC. This interest and support is welcomed by the MFC and it is hoped that this support will continue into the distant future.

The fall season has been very active with 12 hikes to habitats around the Ottawa region, including Green's Creek, Stony Swamp, Mer Bleue, Luskville Falls and Bishop's Mills. Meetings have centered on topic themes with presentations from three to four speakers on each theme. Some of the themes this year included Poisonous Plants and Animals, Preparation for Winter and The Use of Animals in Research. To date we have had great success in the seminars and look forward to the 1987 season.

The 39th edition of *The Little Bear* was published last spring (1986) with contributions from a majority of MFC members. The contributions, editing and production of *The Little Bear* by the members has been an important part of the MFC activities. We look forward to the 40th edition in the 1986-87 season.

A problem which continues to plague the MFC is the low number of active members (Juniors (12), Intermediates (11) and Seniors (11)). The low membership appears in part to be the product of a lack of awareness about the Club and its activities. This year Paul Hamilton started an advertising campaign in an attempt to increase the membership. Some of the local high schools were notified and literature about the MFC sent to the science teachers. This was not successful as not one person expressed an interest in the Club. In November, the MFC participated in the Clubs Day poster session sponsored by the NMNS. Although no new memberships were obtained from the Clubs Day event, an interest in the Macoun Field Club was expressed by many of the people reading the display. Currently the MFC is distributing the Monthly Club Newsletter at the information desk of the NMNS and is trying to get involved with the school programme at the Museum.

Last year the MFC made some noteworthy additions to its library and equipment supplies. An Atari (64K) computer was purchased for the curation of the library. Field binoculars were donated by Robin Collins. Part of the Audubon Field Guide series was purchased for the library and book donations by Martha Camfield and Robin Collins were gratefully received. The MFC also had a sign made for the door of the Club room located in the basement of the NMNS.

The Committee would like to especially thank Rob Lee and Martha Camfield for their support and assistance in running the Club activities.

(P. Hamilton)

1986 MEMBERSHIP IN THE OTTAWA FIELD-NATURALISTS' CLUB*

Type	Canada		Foreign		Totals
	Local	Other	USA	Other	
Individual	420 (450)	243 (266)	53 (59)	6 (5)	722 (780)
Family	301 (309)	24 (28)	2 (1)	0 (0)	327 (338)
Sustaining	48 (36)	4 (3)	0 (0)	0 (0)	52 (39)
Life	15 (12)	18 (18)	3 (3)	2 (1)	38 (34)
Honorary	15 (14)	5 (5)	1 (1)	0 (0)	21 (20)
	799 (821)	294 (320)	59 (64)	8 (6)	1160 (1211)

*These figures are exclusive of non-member subscribers to *The Canadian Field-Naturalist*.

Membership Committee

Eileen Evans (Chairman)	Luella Howden
Eleanor Bottomley	Aillen Mason
Barbara Campbell	Bette Stern
Ellaine Dickson	Ken Strang
Fran Goodspeed	

Club membership declined slightly in 1986. Local membership decreased by 22 and non-local membership decreased by 29. The number of new members joining the Club in 1986 was 129, a decrease of 43 from the 172 who joined in 1985. The total membership of the Club as of December 1986 was 1160, a decrease of 51 from the 1985 total of 1211. Sustaining members totalled 52, an increase of 13 over last year, and life membership showed an increase of 4. Family memberships totalled 327, a decrease of 11 from last year. Based on an average of two members per family, we estimate the total membership served by the Club was 1487.

The accompanying chart [top of page] is a summary of the membership distribution. The figures in brackets are the 1985 totals.

The 1986 volunteer list shows 42 additional volunteers. This list is circulated to the Club Committees and the knowledge and experience of these volunteers will be of significant benefit to the Club.

The membership lists are now on the club computer.

Two honorary memberships were presented, the recipients being E. L. Bousfield and Claude Garton.

The Club lost a valued member in the death of Frank Bell.

The Membership Committee and the Excursions and Lectures Committee again co-hosted the New Members Night on November 14. Seventy people, new members, honorary members, members of Council, and others enjoyed wine, cheese and other refreshments in the mezzanine of the National Museum of Natural Sciences. Many thanks are due to all who worked to make this evening a success.

The Chairman, Eileen Evans, would like to thank all the members of the Committee for their help in 1986, with special thanks to Barbara Campbell, who retired as Chairman in 1985, and to Barbara Martin and Patricia Narraway for their work with the computer.

(E. Evans)

Publications Committee

Ronald Bedford (Chairman)	W. K. Gummer
Barbara Campbell	Jim Montgomery
Paul Catling	Joyce Reddoch
William Cody	John Sankey
Francis Cook	

The Publications Committee carried out its duties as advisory body to Council with regard to the Club's publications.

Four issues of *The Canadian Field-Naturalist* were published in 1986, comprising Volume 99, issue 4, and Volume 100, issue 1-3. The completed Volume 99 is the largest in the history of the journal. With Volume 100 the Club's publications have reached a noteworthy occasion, even though, as pointed out by the editor in issue 1, it marks neither 100 years under this title (68) nor 100 years of continuous publication (107). The four issues published in 1986 included in 580 pages, 45 articles, 53 notes, 87 book reviews, 491 new titles, 2 commemorative tributes and many pages of news and comments that include 6 special reports. Although, due to unforeseen circumstances, the publication schedule is still running late, this does not reflect on the health of the journal. The next three issues are in an advanced state of preparation, and the flow of incoming manuscripts continues at a slowly increasing pace. There was no change in 1986 in the panel of Associate Editors.

Volume 20 of *Trail & Landscape*, comprising 256 pages in 5 issues, was published with the usual fine selection of articles and adherence to scheduling. Preparation of a cumulative index of Volumes 1 to 20 is in an advanced stage. Volume 20 contained a rather higher than usual number of articles concerned with bird study and observations — about 41% of the paging compared with 28% in Volume 19 and 17% in Volume 18. With the demise of *The Shrike*, this emphasis is likely to continue.

As noted a year ago, *The Shrike* was struggling, and in 1986 the Club formally but regretfully announced cessation of publication. No issues appeared in 1986, but it is intended to complete Volume 10 with two issues 4 and 5 that will report on bird sightings during the period August 1985 to February 1986; these should be mailed soon. All 1986 subscription fees were refunded. The reasons for ceasing to publish were the inability to find a new editor, difficulty in finding writers for all of the reporting, and a growing overlap with the column Recent Bird Sightings in *Trail & Landscape*. It is intended that much of the material formerly in *The Shrike* will appear in one form or another in *Trail & Landscape*, especially in an annual report that includes the tabular data. We thank John Sankey for his work as editor for some 18 months, and also the other members of the editorial staff.

One possible Special Publication was considered in depth in 1986, with publication now hinging on receipt of the final revised manuscript for formal review.

The Committee is also acting as the advisory body for a publication on the natural history of the Ottawa area, for which a contract has been let by The Ottawa Citizen for preparation of a draft.

The Publications Committee thanks the large number of people concerned with the publication of these journals, whereby they contribute a dedicated service to the Club.

(R. E. Bedford)

The report was read by W. Gummer, B. Campbell and J. Harrison. After each Committee report there was an opportunity for comments.

(a) *Birds Committee*

E. Dickson noted that there were some non-members listed for this Committee. W. Gummer replied that this had been looked after very recently.

J. Harrison commented that the \$1,300 for the Seedathon seemed low compared to other estimates that he had heard.

W. Cody replied that all funds were not in yet.

(b) *Conservation Committee*

It was commented that the use of acronyms could be confusing. Clarifications will be made as necessary in the report before publication.

(c) *Education and Publicity Committee*

It was noted that the May event for the Girl Guides was the provincial meeting of Girl Guide leaders. George McGee had about 25 helpers assist on the bird-watching tour.

(d) *Excursions and Lectures Committee*

Colin Gaskell expressed a special thanks to Christine Henri who, although not a member of the Committee in 1986, had provided coffee after the monthly meetings, Annual Business Meeting and Christmas Bird Count.

(e) *Finance Committee*

An inquiry was made as to the cost of the microcomputer. W. Gummer replied that the microcomputer cost about \$4400.

G. McGee asked how the Club funds were mainly invested. W. Cody explained that very little money is kept in a savings account, and that the majority is invested in treasury bills and guaranteed investment certificates.

(f) *Macoun Club Committee*

S. Thomson requested that some details of Macoun Field Club activities be added to the Committee report, noting that the report was quite brief. The President agreed that OFNC Council would request a more informative, expanded report from the Macoun Committee, to be reviewed formally by Council at its January 1987 meeting.

[Secretary's note: The above report of Macoun Club Committee is the amended version approved at Council's January 1987 meeting]

E. Dickson noted that, for Macoun field trips, there was a need for more leaders with general knowledge to answer the many questions of the young people.

W. Gummer commended Paul Hamilton, the new Macoun Field Club leader, for having quickly assumed leadership.

(g) *Membership Committee*

D. Brunton noted that honorary memberships are selected as a function of the Awards Committee, so needn't be reported by both Awards and Membership Committees. W. Gummer recommended that, in the future, only Awards Committee would report honorary memberships in the annual report.

D. Brunton moved (2nd J. Sankey) to accept the Report of Council, including the four reports not previously reviewed by Council, with amendments as suggested at the meeting.

(Motion Carried)

5. Nomination of Auditor

F. Pope moved (2nd A. Cameron) that F.M. Brigham be appointed to audit the accounts of The Ottawa Field-Naturalists' Club for the 1986-87 fiscal year.

(Motion Carried)

6. Nominations

Membership on the 1986 Nominations Committee was D.F. Brunton (Chairman), E. Dickson and B. Campbell.

D. F. Brunton announced the 1986 Council members who are retiring:

E. Bottomley	R. Milko
D. Fillman	D. Thompson
B. J. Martin	

The proposed slate for the 1987 Council was presented:

The Executive:	
President	W. K. Gummer
Vice-President	J. Harrison
Vice-President	D. F. Brunton
Treasurer	*F. Valentine
Recording Secretary	*M. Coleman
Corresponding Secretary	B. Campbell

Other Members of the Council:

B. Anderson	*R. John
*B. Bendell	L. Maltby
R. Bedford	F. Pope
A. Cameron	J. Reddoch
W. J. Cody	*W. Smith
F. R. Cook	*K. Strang
E. Dickson	R. Taylor
E. Evans	P. Ward
F. Levine	

*New Member of Council

D. F. Brunton moved (2nd R. Taylor) that the slate of nominations be approved.

(*Motion Carried*)

The President said a few words of appreciation for the retiring members of Council.

7. New Business

- (a) W. Gummer noted that the updated (January 1986) By-Laws and Constitution of The Ottawa Field-Naturalists' Club appeared in *The Canadian Field-Naturalist*, Volume 100, Number 3. The Club By-Laws are mailed to all new members. E. Dickson noted that mailing costs for this practice were high.
- (b) W. Gummer told the meeting that a concerted effort has been made through Council to update the terms of reference of all Committees of Council. D. Laubitz heads an ad hoc group to review these terms of reference for consistency and standardization. In part, the updating exercise will remind Committees that they work for the Club.
- (c) W. Gummer told the meeting that the Ad Hoc Committee on Land Acquisition Policy had submitted a report to the Council. The report allowed that the Club should own land, but the purpose for doing so should be limited to one of four categories. The report recommended that land should not be purchased simply for use as a study area, but should be a natural area worth preserving. The report is on file with OFNC Council.
- (d) W. Gummer announced that the 20-year index of *Trail & Landscape* is nearing completion. In order to determine how many people are interested in the index, the 1987 membership renewal form contained a category for indicating this interest.
- (e) W. Gummer commended Gordon Pringle for his effort to include handicapped people in Club activities. Gordon attended two meetings of the Ottawa Handicapped Association.

- (f) W. Gummer told the meeting that a Computer Management Committee has been formed, whose main responsibility will be assuring maintenance of the microcomputer, determining equipment needs in the future, arrangements for housing the equipment, etc. At present, the computer is being used for membership lists and printing mailing labels for *Trail & Landscape*; other uses may be contemplated in the future. In reply to a question from the floor, W. Gummer remarked that the Club computer is an Eagle Spirit 2 having a 20 megabyte internal hard disk, and Panasonic 1080 printer.
- (g) The President, W. Gummer, thanked Theresa Fuller who is a volunteer typist for the Club, and Christine Henri who has regularly provided refreshments after meetings including this evening's meeting.
- (h) W. Gummer told the meeting that the proposal of M. Bloomfield of the Harmony Foundation of Canada (presented to OFNC members at the October 1986 monthly meeting) was considered by OFNC Council. The Foundation's goals include the establishment at a Canadian university of an interdisciplinary programme in ethics, animals and nature and an endowed chair in environmental ethics. Council felt that the proposal was worthwhile but vague, and asked for more details before giving consideration to endorsing the proposal.
- (i) Roger Taylor told the meeting that the OFNC made a significant contribution to the very successful meeting of the International Ornithological Congress in Ottawa in June. OFNC volunteers participated both in preparations for the meeting, and in activities such as leading early-morning bird-watching tours (three buses daily for 5 days).

8. Adjournment

F. Pope moved (2nd E. Dickson) that the meeting be adjourned. Time: 2147 hrs.

(*Motion Carried*)

9. Following the business meeting, the group met for coffee and dessert and then broke into four discussion groups to discuss various aspects of the Club's activities:

- Awards, Education & Publicity, Macoun
- Birds, Excursions & Lectures
- Conservation
- Finance, Membership, Publications

E. BOTTOMLEY
Recording Secretary

Book Reviews

ZOOLOGY

The Birds of Canada

By W. Earl Godfrey. 1986. Revised edition. National Museums of Canada, Ottawa. 595 pp., illus. \$35.95.

The publication of *Birds of Canada*, revised edition, during the summer of 1986, was a welcome, long-awaited event. Two decades have elapsed since the original "Godfrey" (as it is affectionately known) became a national bestseller. In the intervening years, Dr. Godfrey, now retired from his post as Curator of Ornithology at the National Museum of Natural Sciences, has worked steadily to update and expand his original volume. In this endeavour he was ably assisted by artist John A. Crosby, whose colour plates also illustrated the first edition of the book.

Publication was delayed by many factors, including the necessity to modernize all geographical names mentioned to conform to those published in the recent Canadian *Gazeteer*. The eventual timing of the book could not have been more perfect, however. *Birds of Canada* appeared in time for the 19th International Ornithological Congress, held in Ottawa, 22–29 June 1986. Delegates at this first Canadian (and only second North American) gathering of the international ornithological community were the initial set of people able to obtain and enjoy the book. The volume is dedicated to Percy A. Taverner (the Museum's first Curator of Ornithology) whose own *Birds of Canada* was published nearly half a century ago, and to Robie W. Tufts, who was Godfrey's mentor and friend.

Readers won't be disappointed in the revised "Godfrey." Both the form and content are striking, from its detailed "Table of Contents" through the "Introduction" and species descriptions to its useful "Glossary" and "Index". The book contains many changes from the first edition. Most are obvious improvements. It is a larger book, and not only in actual format. The number of species included and illustrated has been considerably expanded: 578 species occurring in Canada (as opposed to the previous 518) are discussed, and 498 (up from 431) are depicted. Additionally, 37 hypothetical species "recorded in this country on the basis of sight records alone, unidentifiable photos, or unsatisfactory evidence . . ." (p. 11) are briefly described. Moreover, many of the the first edition's shortcomings have been rectified.

The new *Birds of Canada* has better organization and layout. Names of the various orders and families of birds are printed in red, and the text is printed in two columns of unequal width. A narrow one, on the left-hand side, provides the species name: in bold face English, with smaller print French and scientific names underneath it. This is followed by the bird's total length in centimetres and the appropriate page number of the corresponding colour plate. Range maps and Canadian range descriptions (in smaller print) are also part of this section. The main body of the text occupies the right hand column. It includes general descriptions of both adults and immatures of each species, provides measurements, discusses fieldmarks, and supplies data on habitat, nesting, range, and, where applicable, subspecific status. Although food and behaviour are not treated as separate entries, these are sometimes incorporated in special "remarks" — but only for some of the species. It is in these remarks that Godfrey's love of and familiarity with the birds of Canada is most apparent. He writes of the "tousle-headed silhouette of the kingfisher," describes the Wilson's Warbler as a "bright little bundle of animation," and evokes the sight and sound of the prairie summer with its "swirling flocks and high pitched cries of . . . [the] pretty little [Franklin's] gull."

Godfrey is an eminent taxonomist, who has long been associated with the various "Checklist Committees" of the American Ornithologists' Union. It is hardly surprising, therefore, that the new volume contains all up-to-date taxonomic reorganizations, particularly within the family *Emberizidae* and its various sub-families. Moreover, the most recent taxonomic splits are also incorporated. Therefore "new" species of birds include not only those that have been well documented to occur in Canada since 1966, but also newly established species, such as the Pacific Loon, Clark's Grebe, and Red-naped Sapsucker. Other birds have lost their status as full species, among them the Thayer's Gull (reverting to its former status as one of the subspecies of the Iceland Gull), and the Gray-crowned Rosy Finch (now part of the Rosy Finch complex). Recent noteworthy bird records include such 1983 accidentals as the Siberian Ruby-throat and the Stonechat, and those 1984

rarities, the Mongolian Plover in Ontario, and Spoon-billed Sandpiper in Alberta.

The new illustrations, Crosby's colour plates and black-and-white line drawings (together with S. D. MacDonald's drawings, retained from the first edition), greatly enhance the usefulness of this volume. Colour-plates are now placed in groups of eight, each bird's name is next to the actual picture, as are the corresponding text-page numbers. Many birds are included for the first time (e.g. Eskimo Curlew, Ruff, Spotted Redshank, Lapwing, Rufous-necked and Little stints, Spoon-billed Sandpiper, Scissor-tailed, Vermillion, Ash-throated and Brown-crested flycatchers, Black Phoebe, and Painted Redstart). New line drawings illustrate the following species: Rustic, McKay and Snow buntings, Gull-billed, Least, Elegant, Sooty and White-winged terns, Black-backed and White wagtails, and many others.

I applaud the inclusion of a table on the 1941-83 population numbers of the Whooping Crane, but question the usefulness, for the average reader, of a

detailed table of comparative measurements of Western and Semipalmated sandpipers. I also would have liked to see more information on the food of birds, in the form of a separate entry for each species. A somewhat puzzling omission is that of the well-documented large scale invasion of Great Gray Owls in Ontario and Quebec, during the winter of 1983-84. As 419 of these magnificent owls were reported from Ontario and 250 from Quebec, the phenomenon would have deserved inclusion in this up-to-date volume.

I highly recommend this informative, well documented and beautifully illustrated book to every person interested in the birds of Canada. It has a minimum of typographical errors, is written in a charming style, and is very reasonably priced.

MARIANNE GOSZTONYI AINLEY

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An Introduction to Ethology

By P. J. B. Slater. 1985. Cambridge University Press, New York. vii + 195 pp., illus. Cloth U.S. \$39.50; paper U.S. \$12.95.

Peter Slater, well known for his research on bird song and other problems in the development and causation of behaviour, has prepared a lucid and zesty introduction for senior high school and beginning undergraduate students. The material covered extends from the rise of the discipline with Konrad Lorenz and Niko Tinbergen to current developments in approaches to animal behaviour.

Slater begins with the historical background and, along with many in his field, finds it useful to employ Tinbergen's four aims of ethology (the study of causation, ontogeny, function, and evolution) to provide the plan for his material. He then proceeds to the motor and sensory aspects of behaviour, with an examination of reflexes, action patterns, variation and control of motor output, and orientation and migration, followed by one on sensory modalities, ranges, and filters. A motivational review of Lorenz's hydraulic model of animal drive, and features of motivated behaviour such as stimulation and choice mechanisms, justify the conclusion that this topic remains "a daunting one". Developmental issues include learning, instinct, and the nature-nurture controversy.

Evolutionary and functional aspects of animal behaviour lead to considerations of behavioural

genetics, comparisons between species, the origins of displays, behavioural optimization, and sociobiological concepts such as kin selection and reproductive strategies. (Kessel's work on the comparative courtship of balloon flies, cited here as in so many texts, surely bears replication given its flimsy empirical basis.) Finally, aspects of communication and social organization are discussed, including mimicry, messages and meanings, group dynamics, and cultural transmission of information. (The famous opening of milk bottles by British titmice surely is "a classic case of cultural transmission" only if copying behaviour actually occurred.)

This book successfully provides a brisk and good-humoured account of contemporary ethology for its intended audience. The balance between historical contributions and more recent advances is a particular merit, and the biases of some upper-level texts are happily absent. Appropriate examples are adeptly used to support the points made, illustrations are effective, and the light referencing, limited to these illustrations, is supplemented with additional Selected Reading. To all those seeking an authoritative yet palatable introduction to the discipline, Slater's volume will prove an enjoyable experience.

PATRICK COLGAN

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Atlas of Trichoptera of the Southwest Pacific

By Arturs Neboiss. 1986. Series Entomologica, Volume 37. W. Junk, Dordrecht, Netherlands. viii + 286 pp. Dfl. 200; U.S. \$85/£55.50.

The blue-covered atlases edited by Junk are now familiar to many entomologists. The volume on the Trichoptera (caddis-flies) of the Southwest Pacific recently came off the press. This is an excellent book, dealing with 880 species classified into 27 families.

The last three decades have seen a growing concern and awareness of freshwater quality and pollution problems. Surveys established to deal with this field have provided detailed information on aquatic environments using insects as a biological measure of water quality. Such surveys have amassed considerable amounts of material and initiated extensive taxonomic work to enable comparative ecological studies.

The archipelago nature of the SW Pacific-Australian region makes it possible to divide it into five areas, each with a high degree of endemism and its own specific composition of species. Of particular interest is the separation of Tasmania from the Australian mainland as a distinct area.

Australia	335 species
Tasmania	165 species
New Zealand	160 species
New Guinea	152 species
Pacific Islands	48 species

Twenty-seven families are recognised for the above species. The genera and species are grouped on visual similarities, not always adhering to accepted taxonomic arrangements.

A key with some basic illustrations is provided as a general guide to the families. It should be used with discretion due to atypical forms, incomplete information, and unknown characters of the opposite sex. Each family is preceded by a brief diagnosis of its characters and synopsis of its genera. Each generic name is followed by a number indicating the number of species included. Throughout the atlas, species distribution is indicated in an abbreviated form except when restricted to individual islands (name given in full) or for extra-limital records.

For each species a set of illustrations is given which follows a basic format. Leading from left to right are views of male genitalia (lateral, dorsal, and ventral) and, where available, views of female genitalia. The above format is incomplete where illustrations were not available. Sources of the illustrations are listed in the species index. An index of generic and species names (including synonymies) has also been compiled.

This atlas is the first attempt to bring together information on all species described or recorded from this large region and is envisaged as a precursor to future studies. As such, it will be welcomed by all those interested in caddis-flies.

FERNAND SCHMID

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Shorebirds: An Identification Guide to the Waders of the World

By Peter Hayman, John Marchant, and Tony Prater. 1986. Houghton Mifflin Company, Boston, Massachusetts. 412 pp., illus. U.S. \$35.00.

Shorebirds is aimed at those who want to step beyond the traditional field guides. It is a very detailed review of all the shorebird species of the world and is a compendium of information on species identification, ageing, and sexing. It is similar in format to *Seabirds* by Peter Harrison, and is in many ways complementary to that volume.

The book is divided into four sections. The first short section tells how the book was produced and gives information on its use in identifying shorebirds. I suspect many will be tempted to skip this section, but I would recommend against this. It is well written and it will make applying the book in the field much simpler.

The second section is devoted to plates of all the species mentioned in the text. As with *Seabirds*, the illustrations are on the right hand side and the accompanying text is on the left. This text gives the identity of the bird depicted and some brief comments on the key identification points. A map showing summer and winter distribution appears next to the text. The plates usually illustrate between one and three species, showing adults in both breeding and non-breeding plumage and juveniles. The plate style follows the format of the RSPB magazine series called "What's That Bird?", in which large scale illustrations depict the species in its most typical plumages. Smaller-scale insertions show the bird in less characteristic plumages or poses. This is an excellent technique for showing variations in shape due to changes in posture, gradations in plumage, and sub-

specific differences. For example, the Dunlin plate contains 24 separate illustrations of that species. In addition, there are insets of head and tail characteristics. In total, there are 88 plates showing the 214 species covered by this book.

The plates are followed by supporting text, which includes paragraphs on identification, voice, habits, movements (in the migratory sense), plumage description, age and sex characteristics, typical measurements, and references. There are also many black-and-white drawings used to assist in the identification, sexing or ageing process. The final section is a series of appendices giving the principal differences between hard-to-distinguish species, set out in a tabular format.

The written sections are clear and easy to follow, and give concise, yet precise, information. The text is well laid out so that it is easy to select specific sections when required (for example, non-breeding plumage or bare parts). The text accompanying the plates is similarly well thought out, while the maps, although small, serve their purpose. The art work can only be described as heroic. Plate 31, for example, has 34 minutely detailed portrayals of plover species, showing these birds at various seasons and from a multitude of angles. Many of the illustrations also show typical habitat, in a style reminiscent of the great English artist, Archibald Thorburn.

The book arrived for review when the North American shorebird migration was underway. It was therefore possible to make a comparison in the field. In general terms, it appears that the European species and those that occur on both sides of the Atlantic are well done. It soon becomes obvious that there is a distinct European bias (although the title is *Shorebirds*, the term "waders" is used throughout the

text). The painstaking feather by feather portrayals and the detailed season by season plumage descriptions invite an equally painstaking review. When this is done for the North American species, errors and inconsistencies soon surface. The most obvious example is the rendition of Piping Plover on plate 39. It is depicted as a small grey-and-white bird (greyer than the winter plumaged Red Knot), which in no way resembles the "dry sand" colour of a live Piping Plover. On the same page, Killdeer is shown as an over-dark brown bird with a far-too-rich orange rump. These colors are not printer's errors, as they are supported by the description given in the text. Crosby's plates in the new edition of Godfrey's *Birds of Canada* give a much more accurate rendition in terms of colour, shape, and attitude, making them far more useful to North American birders. I am not in a position to make judgements on the accuracy of other non-European species.

I make these criticisms to warn the reader against expecting perfection. However, I strongly urge the purchase of this book as it is unique, fascinating, and immensely useful. It will give hours of pleasure and argument and will promote understanding and identification of this group of birds. If you are serious about your birding and are on a limited budget, this book will be worth the sacrifices that you have to make for it. Indeed, since the local birding fraternity realized I owned a copy of this book (approximately two weeks), I have been receiving phone calls to provide details in sorting out shorebird problems.

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Birds of New Guinea

By Bruce M. Beehler, Thane K. Pratt, and Dale A. Zimmerman. 1986. Princeton University Press, Princeton, New Jersey. 293 pp., illus. + plates. Cloth U.S. \$65.00; paper U.S. \$37.00 (Cdn. \$51.25).

Birds of New Guinea is a standard guide covering 725 species of birds that are known or expected to occur in New Guinea. The official checklist has only 708 accepted bird species. The authors have wisely decided to include 17 additional species which are likely to be added to the list in the near future. The book's introduction has an interesting account of Papuan natural history. This includes a history of exploration as well as a description of New Guinea and its various ecological zones. There is a short but

very useful section of information for visitors to New Guinea.

The species accounts with their attendant plates comprise the remainder of the book. The accounts themselves are short and precise, with each species occupying about a quarter of a page. The information in these accounts has obviously been selected to give the maximum assistance in identification in the minimum space. This economy is understandable, but brevity is often very tantalizing. Some species accounts are brief because of lack of information. This means that even short-term visitors have the potential for adding valuable information to the database.

The art work is by Dale Zimmerman and James Coe. There are 55 plates with 5 in black-and-white and

the rest in color. These depict about 675 species of birds with supplementary black and white drawings for a number of other birds. A few birds are not shown pictorially, but these tend to be wide-spread birds that are depicted in many other field guides (for example, Brown Booby). The art work is professional and essentially accurate. I have only a few minor complaints (for example, the head on the Dollarbird is too green) and could find only one error (the immature and the adult Yellow Oriole are mislabelled).

The birds' distribution is well described in the text. However, the authors should have followed the

current trend and provided range maps. Certainly, they are justified by the cost of the book.

This book, then, is a worthwhile addition to the world's field guides. It is well designed, well printed, and accurate. It will be an indispensable book for any person fortunate enough to visit this tropical paradise. It is also a good gift suggestion for birthdays, Christmas, and so on.

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Aphid Ecology

✓ By A. F. G. Dixon. 1985. Blackie and Son, Glasgow. ix + 157 pp., illus. £17.95.

Aphids are small, fragile, ubiquitous insects of enormous economic importance. They also are extremely fascinating biologically. Aphids demonstrate cyclical parthenogenesis, are capable of tremendous population growth due to telescoping of generations, many species alternate between different species of host plants, and virtually all species are highly polymorphic. Professor Dixon's new book is an extremely well-written account of the ecology of these important and interesting insects, and serves as an excellent complement to his earlier volume *Biology of Aphids* (1973. Institute of Biology Studies in Biology Number 44. E. Arnold Limited, London.).

In this short book Dr. Dixon reviews the current state of understanding of the ecology of aphids, relying heavily on his own extensive research and experience. The central theme of the book is that parthenogenesis and feeding on phloem sap have been major factors in the evolutionary ecology of aphids. The introduction briefly summarizes what little is known of aphid evolutionary history, and presents an outline of aphid classification. Subsequent chapters discuss the relationships of various aspects of aphid biology and ecology as they relate to the success of the group as a whole.

Most aphids have very specific host requirements, polyphagy being the exception rather than the rule. This specificity is probably the result of widespread chemical defenses among plants and the metabolic cost to the aphids of detoxifying mechanisms. Phloem sap is not a rich source of nutrients and one consequence of this has been the evolution of small size as a characteristic of all aphids. This in turn has

had important consequences for growth rates, life history, and dispersal.

The development of cyclical parthenogenesis early in the evolution of aphids led to the development of polymorphism and telescoping of generations. Polymorphism permits a division of labor among morphs adapted to different functions, such as reproduction, dispersal, and survival. (There exist species of aphids having soldier morphs specialized for the defence of colonies. These short-lived soldiers are so highly specialized that they do not feed or reproduce.) Aphid life histories are closely adapted to the nature of their host plants and climatic conditions. Dispersal, feeding, timing of asexual and sexual reproduction, and aestivation closely track the initiation of host growth and senescence and seasonal changes in temperature and photoperiod. The ability of aphids to produce populations of hundreds of millions or even billions of individuals per acre is related to parthenogenesis, the telescoping of generations, and the small size of aphid species.

Aphids are tremendously interesting and *Aphid Ecology* is an excellent introduction to the subject. It is informative, well written, and is amply illustrated with excellent electron micrographs, line drawings, and charts. There is an appendix of the scientific names of aphids referred to in the text, a bibliography of over 400 entries, and an index. I highly recommend this book to anyone interested in entomology or pest management.

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The Wonder of Canadian Birds

By Candace Savage. 1985. Western Producers Prairie Books, Saskatoon, Saskatchewan, 224 pp., illus. Cloth. \$35.00.

Judging by the increasing number of specialized bird books published during the last decade, many authors cater to naturalists interested in the finer points of bird identification, up-to-date information on migration and bird behaviour, and individual species and/or families of birds. Additionally, there have been numerous new field guides for the travelling birder visiting various continents, regions, or countries. To see an attractive book on Canadian birds admirably suited to both the novice and experienced naturalist is, indeed, a rare event. Such a book is Candace Savage's *The Wonder of Canadian Birds*.

At a first glance, this may seem to be yet another coffee table book. It has a large format, is printed on good quality paper, and includes many wonderful colour photographs. A quick perusal of the "Introduction" and/or any portion of the text will reassure the reader that it is nothing of the sort.

Following a brief "Foreword" by Roger Tory Peterson, the author's "Introduction" sets the tone for the well-written, surprisingly comprehensive text. In a highly entertaining style, making full use of an amusing turn of phrase, Savage brings to life 55 species of Canadian birds. She describes their appearance and behaviour (including characteristic peculiarities), informing us of the birds' habitat, food supply, and evolutionary adaptations. Though she does not give the same emphasis to all facets of every species' life history, each essay is an informative self-contained whole, well worth reading and rereading.

Her evocative writing (she graduated with first class honors in English) brings these birds to life. Here are a few examples: After informing the reader that the spiny tent-caterpillars form a large part of the Black-billed Cuckoo's diet, Savage writes (p. 104): "Sometimes it shears the hairs off by working the insects with its bill, though this is by no means necessary. A cuckoo's digestive tract may become

completely studded with spines, yet the bird appears unharmed by its internal hair shirt." On writing about our common eastern hummingbird, she describes it (p. 127) as suspended "between twin halos of green (its motion-blurred wings), a Ruby-throat seems in perfect equilibrium with the air. . . ." Anyone who has ever seen a hummer in flight will not only agree with her, but will think forever of the tiny wings as "halos of green"; I also suspect that tent-caterpillars will conjure up visions of internal hairshirts.

The book is greatly enhanced by over one hundred colour photos, ranging in quality from the very good to superb. Some depict the birds in characteristic postures, while others illustrate typical behaviour discussed in the text, e.g. the American White Pelican's cooperative feeding (p. 27), the Killdeer's typical broken wing distraction display (p. 87), and several species of birds feeding their young. A few photos illustrate rarely seen young birds, such as the Snowy Owl (p. 112) or the two fluffy Nighthawk fledglings (p. 124). Rare photos, such as the one of the head of the Leach's Storm Petrel (p. 19) clearly showing the characteristic tubenose of this species, or one illustrating seldom seen behaviour, such as a Ruffed Grouse running (much like a Roadrunner) over a snowy field (p. 77), provide added interest.

Other features are up-to-date range maps accompanying each species' account, and the impressive list of references grouped at the end of the book. These were gathered from both the scientific and popular literature, although some of the references will only be found in a good university or natural history museum's library. There is also a detailed index.

I enthusiastically recommend this book to all naturalists, beginner or expert, young or old. It will make a lasting gift to relatives and friends, and should be purchased by all community libraries.

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The Breeding Bird Survey: Its First Fifteen Years, 1965–1979

By Chandler S. Robbins, Danny Bystrak, and Paul H. Geissler. 1986. United States Fish and Wildlife Service Resource Publication 157. 196 pp. No price listed.

This publication presents a definitive account of the first fifteen years of the breeding bird survey (BBS), a remarkable labour of love. In each one-degree block of latitude and longitude (six per block in densely settled areas) throughout the United States and southern Canada, a point of origin and a direction are randomly selected by computer, and a 25-mile route laid out. In most of these blocks, two birdwatchers, one as observer and one as recorder, each year follow the same route on a fairly calm, dry June morning, arriving at the starting point half an hour before dawn. There are fifty stops for exactly three minutes each at half-mile intervals, to record every bird heard or seen.

Such observations have now provided for the first time a reasonably consistent, reproducible index for detecting changes in populations of most bird species, especially those occupying habitat near roads. Although less conspicuous species are underrepresented, the consistent methodology allows detection of trends within each species, year by year. The method is not as useful for most colonial waterbirds or for less common species such as most raptors.

This publication provides a wealth of data, divided into 11 pages of methodology, 117 pages of text and maps summarizing bird distribution and population trends, and 27 pages of bird numbers, usually represented as the mean number of individuals per route. An excellent bibliography and eight appendices complete this valuable book.

What are the most interesting results, with special reference to Canada, of all this study by unpaid volunteers? Franklin's Gull has declined in the interior. The Mourning Dove has continued its northward spread, still increasing in numbers. The Common Flicker and Yellow-bellied Sapsucker have decreased while the Downy Woodpecker has increased. The House Wren and American Robin have increased while the Loggerhead Shrike has decreased. The Lark Bunting is declining in the Northern Great Plains. More important, we have a method in place to monitor future effects of changing land use patterns, such as forest destruction in middle and south America, and increasing application of biocides everywhere.

Other potential uses of this databank include monitoring of: range contractions and extensions such as that of the House Finch; effects of severe weather; species composition by ecological regions; habitat correlations; and environmental evaluations. Eventually when we learn more about the proportion of individuals of each species recorded at BBS stops, we may be able to offer a rough estimate of the continental bird population. Meanwhile the information is already proving very useful in compilation of regional bird atlases. We owe a debt of gratitude to Chan Robbins and Danny Bystrak in the United States and Tony Erskine in Canada for a well-conceived plan that has attracted the continued participation of several thousand capable amateur ornithologists.

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Birds of Nova Scotia

By Robie W. Tufts. Revised Edition edited by Ian McLaren. 1986. Nimbus Publishing and the Nova Scotia Museum (co-publishers), 478 pp., illus. \$39.95 (hardcover), \$19.95 (paper).

It is dangerous to undertake revision of a book as well respected as the original *Birds of Nova Scotia* by Robie Tufts. Professor Ian McLaren of Dalhousie University and a team from the Nova Scotia Bird Society not only accepted this challenge but emerged triumphant. They have produced a thorough and excellent revision, retaining that which is good and replacing material that is no longer relevant. The original *Birds of Nova Scotia* by Tufts came out in 1961. It has now become a difficult and expensive book to find. Despite its age it was much sought after as it was the only reference book for Nova Scotia. It

was also worth having for two other reasons. First, in the text Tufts managed to capture some of the charm of Nova Scotia and Nova Scotians. Second, it was illustrated by what I consider some of Roger Tory Peterson's nicest plates. Unlike Peterson's own field guides, these birds are depicted against a natural background. This gives the reader a delightful sensation of atmosphere. These plates have been very sensibly retained in this new edition. There are additional illustrations by John Crosby and line drawings by John Dick. Both of these contributions are professional and artistic, but somehow I feel that Peterson steals the show.

The main text is an account of the bird species of Nova Scotia arranged in the currently accepted taxonomic order. Where appropriate, species names

have been changed to those used in the latest *Check List of North American Birds* by the American Ornithologists Union. The individual accounts cover status, a brief description, breeding (if appropriate), range, and remarks. For vagrant species this is generally reduced to comments on status and remarks only. All the text has been thoroughly revised to bring the book up to date. It is clearly and concisely written yet still retains the maritime flavour of the original author.

Any bird which has been sighted less than ten times is treated as a vagrant. For these birds, details are given from all of the records. Nova Scotia, because of its maritime position, has had more than its fair share of these rarities. The accounts give a satisfying amount of detail and yet the text is written skillfully enough not to be cumbersome.

The remaining migrant and nesting species are given a more expansive treatment. But once again this is not done in a ponderous and rambling fashion. It is remarkable to note how many species have a status that is less than common. This confirms my own experience as I found the "common" birds were much less abundant and harder to find in Atlantic than in Central Canada. However, what Nova Scotia lacks in numbers it makes up in diversity. This can all be gleaned by carefully reading this book.

There are two appendices. Appendix I covers hypothetical species for which no satisfactory supporting evidence exists. Appendix II lists five game birds for which unsuccessful attempts at introduction have been made.

I have only one minor note of criticism. The book contains an excellent map of Nova Scotia (although Ile Madame's coastline is misprinted). However, many of the important places mentioned in the text are not marked (such as Bird Islands, Cherry Hill Beach, etc.). The addition of these names would have been useful and would not have cluttered the map unduly.

I think that Ian McLaren and his team from the Nova Scotia Bird Society must be congratulated on their excellent efforts. Not only have they put a valuable and informative book back in circulation, they have enhanced its usefulness substantially. For the caliber of document produced, the price of \$19.95 makes it an excellent purchase.

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Honeybee Ecology: A Study of Adaptation in Social Life

By Thomas D. Seeley. 1985. Monographs in Behavior and Ecology. Princeton University Press, Princeton, New Jersey. x + 201 pp., illus. Cloth U.S. \$39.50; paper U.S. \$10.50.

Of all the insects, the honeybee is the most well understood by scientists and lay persons alike. Honeybees fascinate us all, no matter what our ages. Children and adults alike may become so engrossed when they watch the hubbub of activity within a glass-walled observation hive that all else is forgotten. There, the challenge to pick out the queen and her retinue of attendant workers, to distinguish the drones, to observe the ministrations of the workers to them, and to observe the incoming foraging worker bees unload their burdens of nectar or pollen and dance their elaborate communication language, all become absorbing. Finding eggs, at the bottom of the cells of the comb, seeing the larvae in various sizes, imagining what it must feel like to be a pupa in a capped-over cell, and struggling along with an emerging adult worker bee as she breaks free of her confining cell, bring out the pleasures of keen observation. Our knowledge that the bees are foraging at flowers for nectar that they will convert to honey

certainly adds to our appreciation of these insects and was, no doubt, the reason for their being domesticated thousands of years ago, their painful stings notwithstanding.

This book is a scholarly treatise on honeybees. Seeley explains the lifestyle, behaviour, and sociobiology of honeybees in the modern framework of evolutionary ecology. He accomplishes this well by drawing on the wealth of literature in apiculture. Much of that has been published in the basic scientific literature, but a large body of information resides in publications devoted to applied biology, especially in agriculture. Seeley has expertly combined both.

Most of the book is about the "European honeybee", *Apis mellifera*, of which several races are commonly domesticated. That bias, which leads to some over-generalizations in the book, is unavoidable because comparatively little is known about the African and Middle-Eastern races of *A. mellifera* or about the Asiatic honeybees, *A. dorsata* (the giant or rock bee of tropical Asia), *A. florea* (the dwarf honeybee), and *A. cerana* (the Asiatic hive bee which is most similar to *A. mellifera* in anatomy and behaviour). Nevertheless, many of the basic general

principles that Seeley elucidates apply to all species and races and at the same time provide, in their detail, interesting comparisons.

Seeley's explanations of social cooperation within honeybee colonies are generally clear. However, such cooperation comes about not without sacrifice in the colony, and its interplay with compromise and conflict at chemical (pheromone) and physical levels provide fascinating insights into sociobiology and the evolution of sociality in insects and other animals. Unfortunately, Seeley catapults his readers into the theories of kin structure, relatedness, altruism, sex ratios, and investment ratio in producing queens and drones, and life history traits. The theories are not adequately explained and Seeley may well mystify some of his readers in the algebra of parts of Chapters 3 and 5.

The lucid descriptions of the annual cycle of colonies of *A. mellifera* in a temperate setting, of colony reproduction and swarming, of the construction of nests, foraging, and the dance language, and of the economics of foraging (which honeybees do for a profit, e.g. honey) more than make up for the problems noted above. Seeley details the precision by

which honeybees control the temperature within their nests, both summer and winter, citing that ability as one of the major innovations made possible by the evolution of their societies. Colony defense is not just accomplished by stinging, altruistic workers, but also by the fastidious cleaning activities in the hive (the removal of corpses, diseased individuals, and outdoor defecation) and the use of plant gums (propolis) as a sticky ant-guard by *A. florea*, or for waterproofing and sealing the nest by races of *A. mellifera* in temperate climes. These facets of the lives of honeybees are described in highly readable detail.

Honeybee Ecology is a splendid synthetic accomplishment. It places some of the recent advances in ecology, sociobiology, and evolution in the context of the biology of an insect with which everyone is familiar. For those reasons I recommend the book to general readers who are interested in ecology, as well as to specialists in behaviour and honeybee science.

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Predator-Prey Relationships: Perspectives and Approaches from the Study of Lower Vertebrates

Edited by M. E. Feder and G. V. Lauder. 1986. University of Chicago Press, Chicago. 198 pp., illus. Cloth U.S. \$26.00; paper U.S. \$11.95.

Much of zoology has been dominated by data based on furry, feathered, or six-legged animals. Based on a symposium, the present volume outlines the benefits for a general understanding of predation to be derived from directing attention to "lower" vertebrates. Predation is a huge topic, of concern to anatomists, physiologists, behaviourists, geneticists, ecologists, and evolutionary zoologists. For all of those interested in these fields, the editors hope to publicize recent research with these animals and to promote interdisciplinary integration. They have successfully encouraged their contributors to downplay detailed data and instead emphasize critical evaluation and speculation.

The nine authors are leading workers who appropriately span the broad spectrum at hand. C. Gans reviews how functional morphology underpins much work on predation, and offers the example of the jaw musculature of skinks. In his chapter on locomotion, P. W. Webb illustrates the route by which descriptive studies lead to tests of predictions of behaviour based on biomechanical principles. Discussing neural mechanisms of prey recognition in amphibia, G. Roth indicates the value of neuroethol-

ogy in predation studies. He argues for a "recognition module" concept in place of the earlier idea of feature detectors, and elegantly outlines the sensorimotor integration underlying feeding sequences. One of his salamanders with its projectile tongue launched against insect prey provides the impressive frontispiece for the book. Energy as a primary medium of biological exchange, and difficulties with its measurement in unrestrained animals, are considered by A. F. Bennett. Turning to the active area of comparisons between species, R. B. Huey and Bennett review the advantages and limitations of descriptive comparisons, and the importance of a phylogenetic perspective for a suite of ecological, mechanistic, and evolutionary questions. They examine issues, such as the use of cladistic analysis, with the case of Kalahari lacertid lizards. H. Greene presents a plea for more study of the natural history of animals as the basis for evolutionary biology, while S. J. Arnold investigates the population genetics of adaptation in terms of variation, selection, ontogeny, and inheritance with comparisons between laboratory and field findings in garter snakes. Defences of each stage of the behavioural sequence of predation are presented by J. Endler, with an example from vision in fish. G. S. Helfman deals with the behaviour of prey fish as a set of conflicts between avoidance of predators and other activities such as reproduction

and migration. The editors close with a call for a broader viewpoint in experimental studies of predation, attention to the natural history of species, and interdisciplinary efforts.

Each chapter is very readable and the critical spirit intended by the editors pervades all of them. The chief merits of the material include a good balance of attention to predators and to prey as well as the examinations of the strengths and weaknesses of the various approaches, such as laboratory and field studies. The need for experimental demonstrations of predation and the importance of ontogenetic data are made very clear. The book is a well written, typical text from the University of Chicago Press which continues to provide the most and finest titles in zoology. References are given at the end of each chapter, and there is an index for subjects, species, and, in splendid isolation, Bernd Heinrich.

By the end of the book the reader has been exposed to an exciting array of problems and techniques in a variety of animals. Perhaps the only group of researchers who can justly feel underrepresented are

ecologists concerned with predation as a regulator of populations and hence as a force shaping communities. With presentations from such a diverse group of workers, it is scarcely surprising that there are occasional terminological difficulties, such as restricting "phenotype" to morphological features to the exclusion of physiological and behavioural ones, and unclear distinctions involving "role" and "function", and "functional" and "evolutionary" biology. Standardization of such terminology is the responsibility of editors. Notwithstanding these blemishes, many topics are introduced in these pages without undue labour. This book is not a comprehensive survey of predator-prey relations, even among heterothermic vertebrates, but it is an interesting slice of the action in experimental zoology.

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A Guide to the Birds of Colombia

By Steven L. Hilty and William L. Brown. 1986. Princeton University Press, Princeton, New Jersey. 836 pp., illus. Cloth U.S. \$95.00; paper U.S. \$42.50.

The heart of any field guide is its illustrations. The plates for the Birds of Colombia have largely been taken from the much cheaper paperback, the Birds of Venezuela. A comparison of the two books clearly shows that the publishers have done an excellent cut and paste job wherever they could. Some of the poorer plates from "Venezuela" have been completely repainted by Guy Tudor. Therefore, the overall quality has improved. This means that birds like the Red-capped Cardinal can be correctly portrayed in its northern form without the back bib.

The text has been completely re-written. It is much clearer and easier to use, with most descriptions occupying one-third to one-half page. Included with the text are some good line drawings by Michel Kleinbaum. These are of birds not illustrated in the color plates. Following the text are some small, but useable range maps.

In addition to the 1695 species covered in the main text, this book also has an introduction which includes short sections on topography, climate, vegetation, habitats, conservation, national parks, and a brief description of Columbian ornithological history. At the rear of the book there are four

appendices. There is a useful section on finding birds in Colombia, a small account of the Colombia-owned Caribbean Islands and a detailed list of the subspecies illustrated in all of the plates. The final appendix is a comprehensive listing of the literature cited in the book.

Overall, the book is a useful, well-produced addition to the ever growing list of field guides. Its purchase is highly recommended for anyone visiting the region. If you are looking for a book that will help identify the rare South American vagrant in North America, or one that will provide you with a general understanding of northern South American birdlife, then "Venezuela" would be a cheaper purchase. Indeed, if you already own "Venezuela" you may wish to think twice about adding this book to your collection.

Reference

Meyer de Schauensee, R., and W. H. Phelps. A guide to the birds of Venezuela. Princeton University Press, Princeton, New Jersey \$35.95 (paper).

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BOTANY

Mountain Flora of Greece, Volume I

Edited by Arne Strid. 1986. Cambridge University Press, New York. xxx + 822 pp., illus. U.S. \$99.50.

This book, as the title indicates, is not a flora of the country of Greece, but rather is a treatment of those species which are commonly found in the mountains above the altitude of 1800 m ("full members") plus species which occasionally reach this altitude or are commonly found in open tree-less habitats above 1500 m ("associate members"). It is the first volume of a proposed two-volume set which treats those families of the Engler and Prantl taxonomic system from the Equisetaceae through to the Plumbaginaceae. In this volume a total of 926 taxa (species and subspecies) are treated, about one-third of which, according to the jacket, were either not recorded for Greece in *Flora Europaea* or were recognized under a different name and/or a different taxonomic rank. The book is thus most important to any taxonomist dealing with alpine plant species that occur in southeastern Europe.

This first volume, in addition to the main body of the text, includes a short introduction which comprises a history of botanical works on the flora of Greece, the scope and format of the flora, botanical exploration, geography, topography and geology, acknowledgements, and a key to the families included in the two volumes.

The body of the text comprises keys, family, generic and species descriptions, habitat and geographic data, bibliographic references, citation of types where available, and synonymy where names have been applied to the Greek flora in the various papers of Halacsy (between 1892–1912), Hayek (between 1917–1928), and in *Flora Aegaea*, *Flora of Bulgaria*, *Flora of Turkey*, *Flora Europaea*, or modern revisions and monographs. Chromosome numbers are also provided where known from the literature, or in greater detail if based on Greek material. The descriptions and keys appear to be sufficiently

detailed for the determination of specimens. Greece is divided into eight geographic regions for the purpose of the flora: Crete, Peloponnisos, Sterea Ellas, S. Pindhos, N. Pindhos, East Central, North Central, North East, Ionian Islands, and Aegean Islands. Within each major geographical region the distribution is indicated briefly, usually giving only the names of mountains on which the taxon has been found, but these data can sometimes take considerable space on the page. Comments are sometimes also provided on taxonomic relationships, subspecies, and interesting distributions.

There are many endemics to the alpine flora of Greece which may be unfamiliar to the North American botanist, but still such circumpolar species as *Oxyria digyna*, *Sagina procumbens*, *Gymnocarpium dryopteris*, or cultivated species such as *Sorbus aucuparia* and the ever-present weeds in our flora such as *Thlaspi arvense*, *Stellaria media*, and *Capsella bursa-pastoris* will be readily recognized.

Twenty-four pages of references, an index to scientific names (with authorities), an index to mountain names, and a list of 46 new taxa and new combinations published in this volume complete the work.

This book, which Strid has edited and written with the aid of some 25 contributors, contains a wealth of information which will supplement *Flora Europaea*. It will be an invaluable source of information on the species found in the alpine regions of Greece for any taxonomist or plant geographer working on the plants of that region. It is to be hoped that Volume 2 will follow quickly.

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The Lichen-forming Fungi

By David L. Hawksworth and David J. Hill. 1984. Blackie & Son, Glasgow. viii + 158 pp. Illus. Cloth £16.95; paper £7.95.

"Lichen associations include some of the oldest living organisms and represent a major nutritional method adopted by one in five fungi." With these words the authors of *The Lichen-forming Fungi* open their preface and at the same time introduce the two

underlying contentions which will guide their pens throughout: first, that lichens possess a much higher interest value than is usually attributed to them; second, that far from being a discrete class of organisms, lichens are really just fungi that happen to feed on algae — it is time someone emphatically introduced them into the mainstream of mycology.

According to the advertisement on the back cover, *The Lichen-forming Fungi* has been written primarily

on behalf of advanced undergraduates and postgraduates specializing in mycology, microbiology, cell biology, phycology, ecology, and biogeography. Maybe so, but the book should not be entirely bypassed by the naturalist community: there is much here that will prove of interest to active minds of whatever background.

Did you know, for example, that only bacteria, of all living things, colonize as many diverse regions of the world as lichens; lichens grow, at their most rampant, some 1000 times more slowly than most other fungi; one algal species can occur in several unrelated lichen species; lichens produce some 550 different chemical by-products, a majority of which occur nowhere else, a few of which may have value in the treatment of some human cancers; or, returning to the preface, some lichen groups extant today were already widely established 225 million years ago, that is, nearly twice as early as the first flowering plants?

Following the preface, the book opens with a consideration of "the lichen habit". Here the authors emphasize that lichens are just one kind of fungus-alga relationship in a fascinating array of such relationships. Then a chapter on lichen structure, followed by another on reproduction. Since it is in these pages that most of the technical terms are introduced, the reader is advised to follow closely here so as to save considerable backflipping later on.

The rest of the book is divided into six chapters, which summarize our latest information on, respectively, lichen dispersal, establishment, and growth; lichen metabolism and physiology; lichen ecology and sociology; lichen biogeography; lichen chemistry; and lichen environmental monitoring potential. At the same time as we are brought up to date on what is known, we are also made aware of those lichenological backwaters where more research is desperately needed.

It becomes abundantly clear, for example, that there is still a major role for naturalists to play in mapping the distribution of lichens, both in remote areas and, just as critical, at home, where the sensitivity of lichens to some forms of atmospheric pollution makes them a useful tool for measuring changes in air quality over time.

Flora of the Great Plains

By the Great Plains Flora Association. 1986. University Press of Kansas, Lawrence. Kansas. 1408 pp., illus. U.S. \$55.00.

In 1977 the Great Plains Flora Association published the *Atlas of the Flora of the Great Plains*. A review of this fine work appeared in 1978 (*Canadian Field-Naturalist* 92(3): 313). Both this and the present work were the brain children of Dr. Ronald L. McGregor of the University of Kansas, who saw the

I have only one quarrel with *The Lichen-forming Fungi*, namely its lack of a workable referencing system. True enough, the book closes with a section entitled "Further Reading", in which nearly two hundred titles are arranged by subject. Still, because this is only a selected listing of the authors' sources, and because, moreover, the titles are not cross-referenced to the text itself, it usually proves impossible to trace any particular fact back to its original source. Thus, although the book often succeeds in piquing the reader's curiosity, it does not go far enough, I believe, in furthering it.

A few small errors can be found. It is not true, contrary to the claim made on page 41, that "soralia and isidia do not occur on the same lichen": a good example of a lichen which produces both is the familiar "lung lichen", *Lobaria pulmonaria*. Likewise, on page 124 the authors imply that *Parmeliopsis ambigua* and *P. hyperopta* differ from one another only as regards their chemistry; in fact they also display quite different physiologies — as seen for example in their differing responses to prolonged snow cover. Trivial errors of this kind are practically unavoidable; *The Lichen-forming Fungi* is remarkable in that it contains so few of them.

All in all, this book deserves a solid place on the bookshelves of any naturalist aiming to build a balanced natural history library. More particularly it can be recommended as required reading for all high school teachers, college instructors, park interpreters, and other individuals whose business it is to deepen public appreciation of the natural world.

In writing *The Lichen-forming Fungi*, Hawksworth and Hill set for themselves the task of winning for lichen study a firmer place in academic biology. Perhaps it is not too much to hope that their effort may leave its imprint upon the naturalist community as well.

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need for such a flora as early as 1940. He has served as Coordinator for the project, with T. M. Barkley, Editor, and R. E. Brooks and E. K. Schofield, associate editors, together with eleven additional members of the Association. With the exception of one individual, all are associated with universities and colleges in the Great Plains area.

The Great Plains area comprises all of the states of Kansas, Nebraska, South Dakota, North Dakota,

Wyoming and Colorado, plus eastern Montana, northeastern New Mexico, and parts of western Minnesota, Iowa, and Missouri, the northwestern part of Oklahoma, and the adjacent portion of Texas. The area treated by the flora is slightly larger than that treated in the *Atlas*, in that a larger part of Montana is included. It is "a natural and floristically coherent region, extending from the base of the Rocky Mountains east to the beginnings of potentially continuous forest and from the Canadian border south to the Texas panhandle region. . . . The Great Plains comprises about a fifth of the land area of the conterminous United States, and it is characterized as principally flat or gently rolling, with only the Black Hills rising to what can be called mountains."

To undertake the writing of a flora of such an extensive region was indeed a great task which has been well done, but because it is a team effort, the results may not all be quite of the same level of detail or taxonomic concept. The treatment is on the conservative side, as may be seen from the lumping of species that some consider to be in separate genera, such as *Minuartia* and *Moehringia* into the all-inclusive genus *Arenaria*, and at the specific level, *Draba cana* into *D. lanceolata*. The order of families is that of Cronquist (1981). An integrated system of classification of flowering plants. Columbia University Press, New York); the descriptions of families, genera, and species are usually in considerable detail. The dichotomous keys appear to be adequate for identification purposes. Chromosome numbers are given for many species, but there is no indication given as to whether or not they are based on plants found within the Great Plains region. Habitats

are given and distributions are provided in an abbreviated form.

Introductory materials include acknowledgments, an introduction which provides a background, a map of the area, and such information as sources of data, sequence of taxa, species concepts, taxonomy and nomenclature, colloquial names, systematic descriptions, distribution, synonymy, authorship and citation, principal references, a brief description of the physical and floristic characteristics of the Great Plains, a list of families in sequence, and a list of abbreviations. Rounding out the book is a list of abbreviations for nomenclatural authorities in which brief sketches of these individuals are provided, a glossary, and a combined index to Latin and common names.

The last book to treat the flora of the Great Plains as a whole was that of P. A. Rydberg in 1932. It is now long out of date, and the concepts in it far from those of modern botanists. Since that time, however, work in the plains has been mainly in the form of state floras or checklists, which naturally have been very uneven in nomenclatural uniformity and taxonomic accuracy. This new work will therefore be a most welcome reference tool on the desk of every botanical student both in the region and areas adjacent. In Canada, in particular, botanists in the southern prairie regions of the provinces of Manitoba, Saskatchewan, and Alberta will find it most useful.

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ENVIRONMENT

Natural Selection in the Wild

By John A. Endler. 1986. Monographs in Population Biology 21. Princeton University Press, Princeton. 336 pp., illus. Cloth U.S. \$40.00; paper U.S. \$13.95.

At the heart of the theory with which Charles Darwin initiated his revolution in biological thinking is the concept of natural selection. From then until the current day the features and importance of this central process have been the focus of much attention. The last couple of decades have seen fresh approaches to the issue, both experimental from molecular biology and theoretical from advanced statistical models in population genetics. As the most recent addition to this prestigious series of monographs, the present volume is a timely and considered evaluation of our

contemporary understanding of this key topic. John Endler is well known for both his empirical studies on the role of coloration in crypsis and predation, especially in guppies, and his conceptual analyses of biogeographical and evolutionary problems.

The terminology and philosophical framework are carefully outlined in the first two chapters. Natural selection is defined as a process in the context of a syllogism including variation, fitness differences, and genetic inheritance of traits. This process is distinguished from genetic drift and evolution (descent with modification). Restricted meanings, especially sexual selection, are described. These usages are traced from Darwin who is quoted appropriately. Distinguishing

the several modes of selection requires knowledge of such features as population variation, the functional relation of fitness to this variation, levels of selection, and modes of inheritance. Logical and semantic problems are dealt with by showing that natural selection is neither a tautology nor a "force acting on a population", and by examining the pivotal concepts of fitness and adaption.

In the next three chapters Endler reviews ten methods available for the detection of natural selection, problems with such detection, and data providing direct demonstrations. Drawing on population genetics and ecology, the methods involve demography, comparison of populations, and correlations with environmental features. These methods enable the use of a variety of approaches to the study of natural selection. As in biology generally, it is important to separate questions of proximate and ultimate causation, of "how?" and "why?" The detection of natural selection or its absence is made difficult by both the complexity of natural communities structurally, dynamically, spatially, and temporally, and biological and statistical shortcomings of obtainable data. Different phenotypes may be selectively equivalent, and unknown correlations may obscure causal relations or prejudice interpretations. Available observations are biased towards vertebrate species and have many defects, such as lack of information on lifetime fitness and restriction to few traits. Although ethologists have long found Konrad Lorenz's insistence that responses be regarded as organs to be useful, they will be surprised to find behavioural studies treated as morphological ones in the review of the data.

The estimation and distribution of selection coefficients and differentials are handled in the next two chapters. For each of polymorphic and quantitative traits there are a number of methods. Although many studies have focused on a single trait, multivariate approaches have the advantage of considering a set of traits simultaneously, thereby operating like natural selection itself and so disposing of the problem of genetic load. Examples support the

arguments presented, such as the tendency to overestimate strong selection and underestimate weak selection. Investigations must embed the study of natural selection within the context of a comprehensive understanding of the overall biology of a species. Reflecting the richness of natural populations, the distributions of selection coefficients and differentials are very variable, with values up to those seen under regimes of artificial selection.

The ubiquity and frequent intensity of natural selection are considered in a final and satisfying chapter. Perspectives on its importance in evolution are given from viewpoints generated by population geneticists, evolutionary biologists, and behavioural ecologists. This analysis illustrates the reason for the current intense controversies on these topics by these various groups with their favoured systems of study, and indicates key problems to be pursued and the need for collaboration in this pursuit.

The book is written in a clear and direct style, thoroughly referenced, and usefully illustrated with examples, figures, and tables, one of which extends over 25 pages. Appendices helpfully absorb quantitative details. The chief merits of the volume are three: first, classification of a cluttered terminology to which many researchers with diverse interests have contributed in often conflicting and confusing ways, second, the summary of the different experimental approaches for the study of natural selection, the underlying theory, the data accruing from each approach, and the associated problems; and third, the placement of the entire topic within the framework of evolutionary theory and the methodology of functional biology. These merits provide a strong basis for Endler's call for detailed and careful examination of natural selection in the wild. The multitude of workers for whom any of these central issues are relevant will find his work to be essential reading.

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The Concise Natural History of New Zealand

By Harriet Fleet. 1986. Heineman, Auckland, New Zealand. 275 pp., illus. (North American distributor, ISBS, Portland, Oregon). U.S. \$19.95.

New Zealand: the main islands alone reach over 13 degrees of latitude and their shores are washed by both the warm waters of the Trade Wind Drift and the cold waters of the circumpolar West Wind Drift. Originally attached to Gondwanaland alongside the

Australian-Antarctica sector, it has drifted out into the Pacific to become the most isolated land mass of its size in the world, now approximately 2000 km from Australia and more than 3000 km from South America. In this isolation a unique flora and fauna have evolved with a high proportion of endemic species. Approximately 80% of its native vascular plants occur nowhere else in the world. The most

extreme of these, *Pennantia baylisiana*, is a small tree that occurs on one of the off-shore islands as a single female plant. As the male flowers are apparently borne on a separate tree, the species will become extinct when this unique tree dies. About 11% of the world's 300 most endangered birds and other animals are endemic to New Zealand and its outlying islands. Many of the endemic birds and insects are flightless, or weak winged, having evolved in isolation from predatory mammals. The natural history of some of the unique plants and animals makes fascinating reading.

Harriet Fleet's guide concisely and comprehensively summarizes the present extent of information covering all species and their ecology. The geographical origin and history of New Zealand, the influence of the wind flows, the relatively recent arrival of man and then European man with his domestic animals, all have had a severe impact of the vegetation and are all used to explain the New

Zealand flora and fauna and what is happening to it today.

The text is organized into the main habitat regions starting in the high mountains, progressing steadily to the sea and the offshore islands. In each region the habitat is discussed in detail, together with the main plant and the animal species found there. Occasionally this does lead to repetition of some information. The book is an encyclopedia in one volume, well illustrated throughout, and an excellent introduction to New Zealand's natural history. It was printed in Singapore. This, and the current low value of the New Zealand dollar, may explain why this hard cover book is such excellent value for money in North America.

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The Machinery of Nature

By Paul R. Ehrlich. 1986. Simon and Schuster, New York. 320 pp. U.S. \$18.95.

One need not go far to find laudatory reviews of this book (Sutton, S. L. 1986. *How the World works. Trends in Ecology and Evolution* 1: 29; Woodwell, G. M. 1986. *Staying alive. Natural History* 94(5): 28-30). It bills itself as "an up-to-date look at what ecologists know about the natural world [, that] shows us where the frontiers of this exciting science are now", and is decorated with sentences of praise by E. O. Wilson, Stephen Jay Gould, Robert Ornstein, Russell E. Train, G. M. Woodwell, Garrett Hardin, and Roger Caras (three of whom are referred to in the text as a "distinguished evolutionist," "a formidable scientist," and a "leader of ecology in my generation"). It is not our intention to contradict these distinguished gentlemen, for they doubtless scanned galleys at great speed, and already acquainted with the content and with Dr. Ehrlich, found the coverage and level of treatment of ecology to be acceptable for an introductory work.

Ehrlich's intention, however, is not to write for them, or for us. He hopes to provide an introduction to ecological theory and practice for the intelligent ignoramus, the "decision makers in Western society" (p. 17) who now do not understand the ecological view of the world, and can, perhaps, modify their professional or personal behaviour once they have learned the ecological world-view. It is difficult to find such people to review the success of such a work. We attempted to evaluate Ehrlich's success in communicating the basic ideas of ecology by reading the book

aloud. We found that regardless of which one of us was reading, the auditor, in frustration, eventually asked the reader to stop. This review is, therefore, a critique of Ehrlich's style of writing rather than of his facts or interpretation.

The book begins as a hurried attempt to explain everything that is needed to develop the "nuclear winter" scenario of world-wide cooling following a major nuclear war. It bursts with anecdotes and topics like unclosed nested parentheses, and rushes out at the reader in a long series of examples, illustrations, and subjects, without ever coming back to the ideas that they were to have illustrated. After the first three chapters it settles down to an orderly progression of ideas, but the style and usage continued to offend us, and might, we suspect, offend an intelligent ignoramus. Many paragraphs seem unedited, as if 100 words were used where 70 would do, and often the second cousin of the correct word is used: "moment" for "concern," "nonrenewable" for "finite," "eatee" for "eaten," "inquisitive" for "would-be," "immobile" for "motionless," "most ferocious" for "largest," "splitting" for "separating," "piece" for "article," "hypothetical" for "possible," "cheap" for "inexpensive," "under the auspices of" for "by," "not well understood" for "unknown," "thoroughly demolished" for "broken," "amounts" for "degrees," and "water-metering" for "water retaining." The "Epilogue" is directed at the U.S. government, and calls for funding for ecological research comparable to that now directed to "biomedical" research.

Ehrlich's "frankly personalized tour of the principles of [this] scientific discipline" (p. 14) entails a lot of self-congratulation. Ecologists are as often "famous" as Chinese restaurants, and whatever Ehrlich or his students have done is first, best, or most wonderful — we are told twice in three pages that Bruce Wilcox is the executive director of Stanford University's Center for Conservation Biology, but the importance of *Anolis* for the study of evolutionary ecology is discussed at some length without mentioning Ernest Williams. Our species is 32 times referred to as "*Homo sapiens*" (including two references in the index where the bi-nomen does not appear in the text), and only one of these is an appropriately taxonomic usage. Because Ehrlich never uses the scientific names of goats, cattle, or other domesticated mammals, this is not the carelessness of an ivory-tower academic who thinks of our species in the same terms as he thinks of any other,

but is, rather, the pseudo-sophistication of a small boy who asks for H₂O in a restaurant.

The Machinery of Nature is a good general introduction to modern ecology, and an interesting book to read through rapidly, but the writing is unfortunately riddled by flaws that may keep it from its intended audience. We may of course not be useful judges of that: perhaps it will remind them of a television nature show or newscast, and make naturalists of them all.

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The Ecological Web

By H. G. Andrewartha and L. C. Birch. 1984. The University of Chicago Press, Chicago. xiv + 506 pp., illus. U.S. \$35.00.

When asked to write this review, I was intrigued, thinking that this book should make interesting and informative reading. After all, when many of us were learning our ABCs of animal ecology, Andrewartha and Birch's first text *The Distribution and Abundance of Animals* (1954. University of Chicago Press, Chicago) was required reading. At that time they presented a persuasive alternative to density-dependent regulation of populations, providing arguments for density independence, and sparking considerable debate among ecologists. Since that time, much has been done to understand and model populations of animals. Unfortunately, Andrewartha and Birch have missed all of it. Major contributions from Lack, Levins, Emlen, Pianka, Hutchinson, Nicholson, and MacArthur are mentioned only in passing or omitted altogether. Instead, we are offered a tedious, wordy theory about the distribution and abundance of animals, wherein the concept of "spreading the risk" could easily be construed as group-selectionist.

Mathematical models are dismissed for not providing testable hypotheses. We are given word models (envirograms), which are nothing more than

the first step towards a mathematical treatment. The envirograms offer several new words and new meanings for others.

Among the examples given in the discussion of ecological principles (i.e. density-independent population regulation) is that of the Spruce Budworm (*Choristoneura fumiferana*) in New Brunswick. The only reference used is essentially that of R. F. Morris (Editor. 1963. The dynamics of epidemic spruce budworm populations. *Entomological Society of Canada Memoir* 31: 1–332). This work was criticized by T. Royama (1981. Evaluation of mortality factors in insect life table analyses. *Ecological Monographs* 51: 495–505) based on a lack of understanding of density-dependent factors and inappropriate statistical analyses. Andrewartha and Birch do not address these points.

Most of the text involves insect ecology, except for a few curiously out-of-place case studies from elsewhere in the animal kingdom. As a dialectic, the book fails and I suggest that it be avoided by those wishing to study animal ecology. Others may wish to read it out of idle curiosity.

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MISCELLANEOUS

Information in Biological Systems: The Role of Macromolecules

By Werner Holzmüller. 1984. (Translation of 1981 German original). Cambridge University Press, Cambridge. ix + 147 pp., illus. Cloth U.S. \$32.50; paper U.S. \$9.95.

Professor Holzmüller is from Karl Marx University of Leipzig, East Germany. He is a physicist with a specialty in chemical polymers (like nylon and polystyrene). He sets out to explain life starting from the physics of molecules, using the precepts of dialectical materialism as a guide. All this sounds quite ominous, and unlikely to appeal to the sensibilities of a field-naturalist. Yet, against all odds, it turns out to be a calm, humane, and attractive view of life, ending with these lines from Tychev:

"Nature is not what you think, it is not a cast, a soulless face. It has a soul, in it is freedom, in it is love, it speaks to us."

The author is uncompromising in his basic principles, and spells them out explicitly. The most important ones are that "all life processes including thinking, feeling and volition are connected with material, recognizable chemical processes in macromolecular systems" (note he does not say "determined by") and that "macromolecular systems obey the laws of thermodynamics without exception". These appear rather stark when written out in full, but are in fact part of the toolkit of every biologist, although they are rarely articulated so clearly.

The first part of the book is a straightforward treatment of biological macromolecules from the perspective of a physical chemist. The combination of molecules and thermodynamics gives him direct access to the three basic currencies of all systems, including living ones, namely energy, matter, and information. The second law of thermodynamics has to do with entropy, the converse of information, hence the title of the book. For those of us who use the

energy/matter/information formalism for understanding ecosystems, this is a very useful summary, more sophisticated than that found in most ecological texts, yet still understandable. Unfortunately, he does not refer directly to any ecological examples, even though some parts of ecology (e.g., the Shannon-Wiener index of diversity and exploration of mathematical chaos in population models) are closely connected with information theory.

The last section of the book opens with the modest disclaimer that its concepts "represent my personal opinion and, being to some extent novel, are intended to stimulate discussions". Here he discusses how the store of biological information accumulated on earth, and decides that plausible rates of conventional evolution are too slow to account for it. He thus turns to Hoyle and Wickramasinghe's theory of panspermia, otherwise known as "viruses from space". This decidedly unconventional theory, which has been in the news again recently (see for example *Nature* 321 p. 723, and *Nature* 322 p. 509-511) is treated with angry contempt by most scientists in the West, so it is fascinating to see it taken seriously by an east European. It is an eloquent illustration of how closely science and society are still interlinked, no matter how much "pure scientists" would wish to deny it.

The final conclusion of the book is that "we are not the only living beings in the universe". Holzmüller may have lost most readers by this point, but it is a pleasure to follow him at least part way down such unbeaten paths when the excursion is led with such calm scientific rigour.

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Galapagos: A Natural History Guide

By M. H. Jackson. 1986. University of Calgary Press, Calgary, Alberta. xiii + 284 pp., illus., \$17.50 + \$1.50 postage.

The Galapagos Islands off the Equadorian coast have done much to change our vision of life on this planet. Darwin first raised the world's awareness of these tiny land masses with his revolutionary theory of evolution. Since then we have more fully realized our role as part of a ecological community, and much of this understanding has stemmed from the scientific

work done on Galapagos. Michael H. Jackson has transcribed this information into a comprehensive book for the non-scientist.

The author explains the geological and then human history that created and focussed the attention on these small tropical islands. He sets the stage by explaining the environmental parameters of climate and ocean current which give them their unique character. From this basis he proposes the most likely events which resulted in the colonization by the

founding species. His explanations for the evolution and adaptation of the various unique species and sub-species is both rational and interesting. Equally thought provoking are his comments on the lack of certain species and his reasoning on why this should be.

The author then devotes a chapter to each of the following: plant life, reptiles, sea birds, coastal birds and migrants, land birds, native mammals, terrestrial invertebrates, and intertidal marine life. The chapter on plants, while not exhaustive, is sufficient to give a solid understanding of Galapagos' plant communities. The reptiles are dealt with in somewhat more detail, especially the Giant Tortoise. The author has chosen to treat the birds in much greater detail than the other life forms. I feel this is a wise decision as this will be the major interest of most non-scientific visitors. Although the author gives brief identification notes, this book is not meant as a field guide, but concentrates on ecology and occurrence. The section on Darwin's finches is entertaining and informative.

The chapter on mammals is brief but adequate for all except the whales and dolphins. I would have preferred a little more information on the abundance and seasonal distribution of whales. The chapter on terrestrial invertebrates is also very brief, perhaps necessarily so. It does however give a reasonably good feel for the insect and similar life of the islands.

The account of the intertidal and marine life is a useful inclusion, especially in view of the importance that the ocean's influence has on the wildlife. The chapter on conservation is an interesting but somewhat dismaying account of how human activity has played havoc with this unique ecosystem. The author does not leave us in complete despair, however, as he shows that there are solutions. Some work has already been done to preserve and restore the natural conditions. Unfortunately, a complete reversal of human errors does not appear possible. Like all research work, the Galpagos scientific effort is

underfunded and it is not likely there will ever be enough money to tackle anything more than the most important problems. For example, the author estimates there are one-hundred thousand goats on San Diego Island alone. To eradicate this one species from this one site would be difficult, exhausting, and expensive.

The book finishes with a chapter for visitors giving much pertinent information and some useful site guides. This section is well illustrated by clearly drawn maps of most important regions.

The book is illustrated throughout by photographs. Some, in colour, appear at the beginning of the book, but the majority are in black and white. They have been carefully chosen and integrate well with the text. There are also various other maps, tables, and drawings which add to the usefulness of the book.

In general, the text is thoughtfully prepared, easy-to-read, and informative. The author does have an irritating habit of unnecessarily repeating himself on many occasions. The book is also marred by a few typographical errors although these do not appear to confuse the sense of the narrative. The author has incorrectly listed Semi-palmated and Ringed-Plover as the same species. The illustration labelled "Noddy" is far too pale to be a Brown Noddy (the only noddy species mentioned in the text). A little more prudent proof-reading would have eliminated these errors.

Despite the few, relatively minor, problems mentioned above, this book is a worthwhile purchase. It is clearly aimed at the ever increasing number of visitors to the Galapagos and will provide them with a valuable and enjoyable account of the ecology of the islands. The author's explanation of colonization and evolution will make the visitor's trip more meaningful. I am sure Charles Darwin would have approved.

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NEW TITLES

Zoology

Advances in animal conservation. 1985. Edited by J. P. Hearn and J. K. Hodges. From a symposium, London, May, 1984. Clarendon (Oxford University Press), New York. xx + 282 pp., illus. U.S. \$69.

***Animal intelligence: insights into the animal mind.** 1986. Edited by R. J. Hoage and Larry Goldman. Smithsonian Institution Press, Washington. 207 pp., illus. U.S. \$10.95.

†Animals of the western rangelands: a test to survive and thrive. 1986. By Ernest H. Elms. Naturgraph, Happy Camp, California. 224 pp. Cloth U.S. \$14.95; paper U.S. \$8.95.

Animals without backbones. 1987. By Ralph Buchsbaum, Mildred Buchsbaum, John Pearse, and Vicki Pearse. Third Edition. University of Chicago Press, Chicago. c584 pp., illus. Cloth cU.S. \$25; paper cU.S. \$17.

†**The Arctic and its wildlife.** 1986. By Bryan Sage. Facts on File, New York. 192 pp., illus. U.S. \$24.95 in U.S.A.; \$34.95 in Canada.

Barawa and the ways birds fly in the sky. 1986. By Michael Jackson. Smithsonian Institution Press, Washington. xii + 212 pp., illus. U.S. \$18.95.

The behavior of teleost fishes. 1986. Edited by Tony J. Pitcher. Johns Hopkins University Press, Baltimore. xvi + 533 pp., illus. U.S. \$57.50.

The beginning of the age of dinosaurs: faunal changes across the Triassic-Jurassic boundary. 1987. Edited by Kevin Padian. Cambridge University Press, New York. c432 pp., illus. cU.S. \$75.

†**A birder's guide to Trinidad and Tobago.** 1986. By William L. Murphy. Peregrin Enterprises, College Park, Maryland. v + 124 pp., illus. U.S. \$12.95.

***Birds of the Rocky Mountains.** 1986. By Paul A. Johnsgard. Colorado Associated University Press, Boulder. 516 pp., illus. Cloth U.S. \$39.50; paper U.S. \$16.95.

***A coded workbook of birds of the world, volume 1: non-passerines and volume 2: passerines.** 1986. By Ernest P. Edwards. Author, Sweet Briar, Virginia. 156 pp., illus., and c180 pp., illus. U.S. \$12 and U.S. \$15. Also available in computer disk, price not given.

The Collins encyclopedia of animal behaviour. 1986. Edited by Peter J. B. Slater. Collins, London. xvi + 144 pp., illus. £9.95.

The Collins encyclopedia of animal biology. 1986. Edited by R. McNeil Alexander. Collins, London. xvi + 144 pp., illus. £9.95.

The Collins encyclopedia of animal ecology. 1986. Edited by Peter D. Moore. Collins, London. xvi + 144 pp., illus. £9.95.

Cowries of the world. 1985. By C. M. Burgess. Gordon Verhoef and Seacomber Publications, Orlando, Florida. xvi + 289 pp., illus. U.S. \$95.

CRC handbook of animal diversity. 1986. By Richard E. Blackwelder and George S. Garoian. CRC Press, Boca Raton, Florida. 568 pp. U.S. \$195 in U.S.A.; U.S. \$225 elsewhere.

Current ornithology, volume 4. 1986. Edited by Richard F. Johnson. Plenum, New York. c300 pp. U.S. \$45.

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Dragonflies. 1987. By Peter Miller. Cambridge University Press, New York. c80 pp. Cloth cU.S.\$34.50; paper cU.S. \$14.95.

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The ecology of woodland rodents: bank voles and wood mice. 1985. Edited by J. R. Flowerdew, J. Gurnell, and J. H. W. Gipps. From a symposium, London, November, 1984. Clarendon (Oxford University Press), New York. xx + 418 pp., illus. U.S. \$79.

Fire ants and leaf-cutting ants: biology and management. 1986. Edited by Clifford S. Lofgren and Robert K. VanderMeer. From a conference, Gainesville, Florida, March, 1985. Westview, Boulder, Colorado. xvi + 435 pp., illus. U.S. \$45.

***The freshwater fishes of Europe, volume 1: Petromyzonidae.** 1986. Edited by Juraj Holcik. Aula-Verlag, Wiesbaden, Germany. 313 pp., illus. DM 236.

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The insects and arachnids of Canada, part 14: the grasshoppers, crickets, and related insects of Canada and adjacent regions (Ulonata: Dermaptera, Cheleutoptera, Notoptera, Dictuoptera, Grylloptera, and Orthoptera). 1985(1986). By Vernon R. Vickery and D. Keith McE. Kevan. Publication 1777. Agriculture Canada, Ottawa. Illus. \$36.95 in Canada; \$44.35 elsewhere.

Investigations into the effects of acid precipitation on wetland-dwelling wildlife in northeastern Ontario. 1986. By Peter J. Blancher and Donald K. McNichol. Technical Report No. 2. Canadian Wildlife Service, Ottawa. 153 pp., illus. Free.

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North Atlantic nudibranchs (Mollusca) seen by Henning Lemche. 1985. By Hanne Just and Malcolm Edmunds. Ophelia Publications, Helsingør, Denmark. vi + 170 pp., illus. D.Kr.50.

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Botany

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Biologie végétale: plantes supérieures, volume 1: appareil végétif. 1986. Par Robert Gorenflot. Second edition. Masson, Paris. xii + 238 pp., illus. F 110.

The botanists: a history of the Botanical Society of the British Isles through a hundred and fifty years. 1986. By David Elliston Allen. St. Paul's Bibliographies Winchester, England. xvi + 232 pp., illus. + plates. U.S. \$25.

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Flora of Kuwait, volume 1: Dicotyledoneae. 1985. By Hazim S. Daoud. Revised by Ali Al-Rawi. KPI, Boston. xii + 224 pp., illus. U.S. \$75.

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Flora of the British Isles. 1987. Edited by A. R. Clapham, T. G. Tutin, and D. M. Moore. Third edition. Cambridge University Press, New York. c1000 pp. cU.S. \$150.

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Cover: Shumard Oak, *Quercus shumardii*, located in Malden township, Essex County, Ontario, J. Ambrose 2978 (CAN, OACA) photographed 13 October 1982. Courtesy Steven W. Aboud, see article pp. 532-538.

Roost Characteristics and Roosting Behaviour of Black-billed Magpies, *Pica pica*, in Edmonton, Alberta

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From November 1983 to April 1985, observations were made of the communal roosting activity of Black-billed Magpies (*Pica pica*) at 12 sites located near or within the North Saskatchewan River valley in Edmonton, Alberta. The earliest occurrence of communal roosting following the breeding season took place in late June. The birds then roosted in dense (10 870-14 510 trees/ha) thickets of deciduous trees (mainly *Populus* spp.). Such roosts were used inconsistently until permanent snow cover was established (October-November). Thereafter, and until the end (March-April) of the communal roosting season, magpies regularly spent the night in dense (2200-14 900 trees/ha) stands of spruce trees (*Picea glauca*). The number of roosting magpies reached a small peak (up to 78 birds) around December, and a larger peak (up to 150 birds) in February-March. This second peak coincided with, and may have been caused by, the occurrence of conspicuous social displays at the largest roosts. The birds arrived daily at the roosts during the hour preceding sunset, and departed from them during the 45 min preceding sunrise. Arrival and departure spanned 35-71 min and 2-23 min, respectively. While in the roosts, magpies were never seen to huddle, even under the coldest temperatures (-23°C). Extensive (> 50%) overhead cover and important (> 70%) reduction of wind in the coniferous roosts probably helped the birds to cope with cold in winter. Magpies also tended to sleep amid dense networks of branches in both deciduous and coniferous roosts, a possible adaptation against nocturnal avian predators such as Great Horned Owls, *Bubo virginianus*.

Key Words: Black-billed Magpie, *Pica pica*, roosting behaviour, roosts, urban river valley, Edmonton, Alberta.

The Black-billed Magpie, *Pica pica*, is a medium-sized corvid whose distribution range extends from Alaska to central California and western Texas (Lindsay 1937). Throughout this range, the magpie is an opportunistic beneficiary of human settlement (Lindsay 1937; Salt and Salt 1976). It is particularly abundant in Edmonton, where it is a year-round resident. Here it finds appropriate nesting trees in summer, and an abundance of food sources resulting from human activity (e.g. garbage, bird feeders) that help it survive in winter.

Habitat requirements of the magpie also include suitable roosting cover. This is particularly critical in winter, when nights are long and cold. Dense thickets of deciduous trees or scrub are the magpie's preferred habitat for roosting (Goodwin 1976). However, northern populations have been reported to roost in coniferous stands in winter (Gyllin and Källander 1977; Mugaas and King 1981). This is probably an important behavioural adaptation to cold, yet no quantitative data exist on the nature of these coniferous roosts and their seasonal use by magpies.

The magpie's roosting behaviour itself is poorly documented.

To quantify the roosting habits of magpies in winter, I studied 12 roosting sites located in central Edmonton over a period of two years. The study had three objectives: (1) to quantitatively describe the habitat used for roosting, (2) to assess the seasonal use of the roosting sites by counting the number of magpies present in them throughout the year, and (3) to describe the general behaviour of magpies at the roost.

Study area and methods

Edmonton (53°30'N, 113°30'W) receives on average 314.4 mm of rain and 132.1 cm of snow annually. Average daily minimum and maximum temperatures are -19°C and -10°C in January, and 12°C and 23°C in July. Sub-freezing night temperatures occur regularly from October to April. Day length (sunrise-sunset) decreases from a maximum of 17.0 h in June to a minimum of 7.5 h in December.

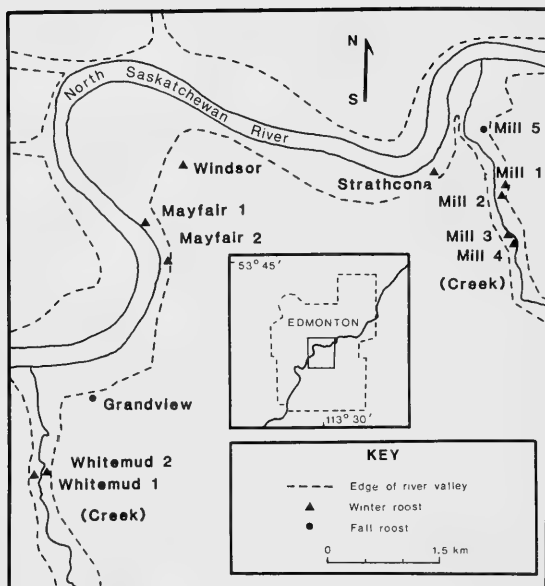


FIGURE 1. Location of the study area and the magpie roosts in central Edmonton, Alberta.

In Edmonton, magpies are found mostly near the North Saskatchewan River (Figure 1). The adjacent river valley is 1.0–1.5 km wide, 50 m deep, and consists mainly of steep wooded slopes and flat open spaces. White Spruce (*Picea glauca*) and Trembling Aspen (*Populus tremuloides*) are the main tree species in the valley. Some Balsam Poplar (*Populus balsamifera*) and Paper Birch (*Betula papyrifera*) are also present. The main shrub species are Hazelnut (*Corylus cornuta*), Chokecherry (*Prunus virginiana*), Pincherry (*Prunus pensylvanica*), Thinleaf Alder (*Alnus tenuifolia*), and Wild Rose (*Rosa acicularis*).

The study was restricted to the south side of the river between Whitemud Creek and Mill Creek (Figure 1). From November 1983 to April 1985 I followed magpies from their daytime ranges to their roosting sites. Twelve roosts were found (Figure 1). I noted the behaviour of the magpies as they arrived at the roosts in the evening and departed from them in the morning on numerous occasions throughout the study.

Two of the roosts were in well-delimited deciduous thickets (see results). I estimated tree density in these roosts with the point-centered quarter method (Cottam and Curtis 1956), using a total of 21 sampling points along seven equidistant parallel transects (three points at 10-m intervals on each transect line). Only trees over 2 m high were considered. The four trees

used at each sampling point were also measured for height and DBH (diameter at breast height). Height was measured with an Abney level.

Nine roosts were in well-delimited coniferous stands on the slopes of the river valley or adjacent tributaries (see results). All trees present in the stands and higher than 2 m were counted and measured for (1) height, (2) DBH, (3) number of lateral branches longer than 15 cm in the lowest 6 m, (4) number of neighbouring trees within 1 m, and (5) height of the lowest 1-m interval that had at least five branches bearing needles. The latter measure was averaged for all trees within each roost to estimate the height of the lower boundary of the living canopy. Tree density was calculated by dividing the total number of trees by the horizontal surface area. Percentage of coniferous overhead cover was estimated visually (in classes 0–10%, 10–20%, etc.). Inclination of slopes was measured with an Abney level, and the direction slopes were facing was estimated with a compass. Another roost (Windsor) was not in uniform habitat (see results) and no extensive habitat analysis was conducted in it.

Temperature and wind speed were measured in one roost, Whitemud 2. This roost was chosen because it was intermediate in altitude between two unused coniferous stands which were located next to it on the slope and with which comparisons could be made. For 21 days in February 1985, temperature was recorded continuously and simultaneously in all three stands, using three Wilhelm Lambrecht hygrothermographs, each one positioned 3 m high against the bole of a spruce tree. Wind speed was measured on three windy days in February 1985, using a hand-held vane anemometer (Negretti and Zambra Inc.). Single wind measurements were made successively, in a random order, in each stand as well as in an open field outside the valley. This was repeated twice each day, using a different random order each time, and those three daily measurements were averaged for each location.

Morning counts of departing magpies were made about once a week in the fall of 1984 and in the winters of 1983–84 and 1984–85 at Windsor, Grandview, both Mayfair roosts, and all Mill Creek roosts. These roosts were chosen because a vantage point was available from which all departing magpies could be seen. Data were pooled for the two Mayfair roosts and for the four Mill roosts, as movements from roost to roost often occurred within these two sites throughout the winter.

Results

Habitat features at the roosts

Grandview and Mill 5 were deciduous roosts. The Grandview roost was a dense thicket of young aspen

TABLE 1. Topographic and vegetative features of nine winter roosts used by Black-billed Magpies in Edmonton, Alberta.

Roost	Area (m ²)	Slope		Position of roost on slope	No. trees/ha		Cover height ² (m)	Tree characteristics (X ± S.D.) ³					
		angle	facing ¹		total	living spruce		%	height (m)	DBH (cm)	branches ⁴	neighbours ⁵	n
Whitemud 1	140	39°	45°	middle	14900	9000	85	4.1	7.2 ± 2.5	6.8 ± 3.4	85.8 ± 16.2	4.7 ± 2.2	126
Whitemud 2	138	28°	290°	middle	12800	5100	75	7.4	12.3 ± 4.0	11.4 ± 5.2	83.1 ± 21.8	4.7 ± 2.3	70
Mayfair 1	139	0°	(216°)	bottom	4700	2600	55	5.5	9.9 ± 3.3	10.7 ± 3.4	84.7 ± 24.3	1.3 ± 1.1	36
Mayfair 2	291	25°	232°	top	3600	2700	55	6.4	11.3 ± 4.3	11.1 ± 5.3	56.3 ± 15.0	1.6 ± 1.4	79
Strathcona	244	20°	325°	top	4800	3300	65	4.3	8.4 ± 2.8	11.0 ± 4.4	61.0 ± 18.7	1.3 ± 1.0	81
Mill 1	169	16°	264°	middle	3300	2400	75	5.4	11.2 ± 3.6	13.1 ± 5.5	76.0 ± 16.4	0.8 ± 1.0	41
Mill 2	239	21°	288°	middle	3000	2500	65	7.3	12.9 ± 4.4	12.9 ± 5.2	60.3 ± 16.5	0.7 ± 0.7	60
Mill 3	540	30°	44°	bottom	2200	1800	75	6.3	12.5 ± 5.2	14.3 ± 7.0	70.5 ± 20.2	0.6 ± 0.7	96
Mill 4	158	28°	52°	bottom	4300	3000	75	5.2	9.0 ± 5.1	10.6 ± 8.1	81.9 ± 13.6	1.7 ± 1.1	47

¹0° = north, 90° = east, 180° = south, 270° = west.²Lower boundary of living canopy.³Living spruce only.⁴Number of branches in the lowest 6 m.⁵Number of neighbouring trees within 1 m.

located on a flat expanse of terrain between residential houses and the edge of the river valley (Figure 1). The Mill 5 roost was a dense thicket of Paper Birch, Balsam Poplar, and various shrubs on the west-facing slope of the Mill Creek ravine (Figure 1). Tree density in the two deciduous roosts, Grandview & Mill 5, was estimated at 14 511 and 10 873 trees/ha, respectively. The trees averaged 6.1 ± 1.7 (S.D.) and 5.1 ± 2.4 m high, and 5.9 ± 2.7 and 5.2 ± 3.8 cm DBH at the same sites. Only a few trees were taller than 8 m.

The coniferous roosts (Table 1, Figure 1) consisted of tall and slim spruce trees whose crowns intermeshed to provide more than 50% overhead cover. Presumably because of this cover, the lower half of these trees was totally defoliated, leaving an extensive array of dead branches (Table 1) on which the birds could perch. Small spruce snags were also present in the roosts but did not appear to be used by magpies for perching, as no droppings were found on or below them. Total tree density (including snags) in the coniferous roosts varied from 2200 to 14 900 trees/ha but was mostly within the range of 3000–5000 trees/ha. Living spruce trees represented on average 67.2% of that total. All roosts were located on slopes facing either eastward or westward (Table 1, Figure 1).

Among these nine coniferous roosts, roost trees (spruce bearing droppings) represented 25–72% of all living spruce. Within each roost, the distribution of the individual values of DBH, height, number of branches in the lowest 6 m, and number of

neighbouring trees within 1 m for roost trees greatly overlapped with that of non-roost trees. There was no significant tendency, among the nine roosts, for the mean values of roost trees to be consistently higher (or consistently smaller) and those of non-roost trees ($P > 0.02$, two-sided Sign test, $n = 9$).

The magpies occupied those sides of the roost trees with the longest and most numerous branches. The downslope side of most trees bore longer and more numerous branches than the upslope side. Under such trees, droppings were always found only on the downslope side of the trunk. In the case of a few trees with a uniform distribution of branches around the trunk, droppings could be found on all sides.

Wind speed in the Whitemud 2 roost was less than 10% of that recorded in the open field (Table 2). Wind reduction was greater in the roost than in the coniferous stand above it on the slope, but slightly less than in the stand below (Table 2). Temperature in the roost at night (0200 h) was also intermediate between the other two stands (Table 2).

The remaining roost (Windsor) was located in a residential area. No extensive deciduous or coniferous stands were present there, but the area included many spruce hedgerows (22 clumps or rows of three trees or more in a 4.03 ha area). The magpies roosted within these hedgerows in winter. Good cover and intricate networks of branches could be found within the hedgerows, as a dense growth of needles was born by the topmost branches and by the outer third of the

TABLE 2. Average temperature ($^{\circ}\text{C}$, center) and wind speed (right) at three different altitudes on a west-facing slope entirely covered by coniferous stands in Whitemud Creek, Edmonton. The wind speed is expressed as a percentage of the speed that was recorded concurrently in an open field above.

Altitude above sea level (m)	Position in slope	Time (MST)				Wind direction and speed (km/h) in the open		
		08:00	14:00	20:00	02:00	SE 24.4	NE 26.1	NW 19.4
664	top	-5.4	2.7	-1.6	-4.3	28.7%	22.6%	33.0%
649	middle ¹	-6.6	0.1	-3.4	-5.6	9.8%	8.4%	26.8%
635	bottom	-8.4	1.3	-3.3	-6.6	4.9%	5.0%	29.9%

¹Location of a magpie roost.

lower branches, leaving the innermost part of the trees with numerous bare, branching limbs.

Seasonal roosting activity

In 1984, the first signs of communal roosting activity following the breeding season were observed at the two deciduous roosts. Mostly family groups of 4 to 6 birds were involved. From June to October-November, communal roosting occurred inconsistently at these sites, with numbers fluctuating between 0 and 116 (Grandview, Figure 2) or 0 and 40 (Mill 5, Figure 2).

In both years the magpies abandoned the deciduous roosts and moved to the coniferous roosts a few days after the first important snowfall of winter left a permanent snow cover on the ground. In both cases,

the establishment of a permanent snow cover was accompanied by a decrease of about 5°C in night temperatures. The nightly lows varied between 0 and -5°C before the snowstorm, and between -5 and -13°C during the first few days following it (data obtained from the Edmonton Weather Office). Before the snowfalls, the deciduous trees in which magpies were roosting had been leafless for 1 to 4 weeks.

The roosting populations at the winter sites were either small and slightly decreasing in size (Windsor and Mayfair, Figure 2) or large and generally increasing in size (Mill Creek, Figure 2). The data at Mill Creek suggest two annual peaks in the number of roosting magpies (Figure 2). The first appeared to occur in December of both years. The reality of this

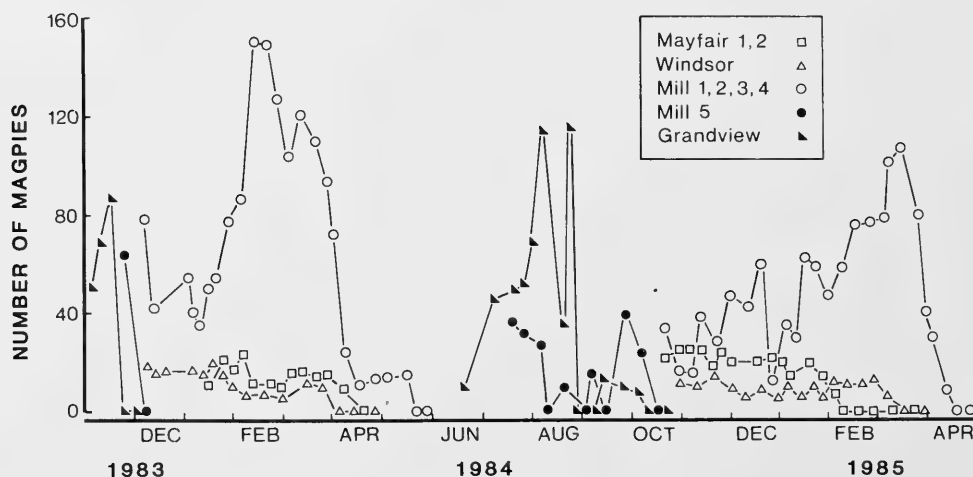


FIGURE 2. Number of magpies counted at five roosting sites in Edmonton, Alberta, from November 1983 to April 1985. The Mayfair data represent two roosts combined, and the Mill data represent four roosts combined. Solid symbols indicate fall roosting in deciduous thickets, while open symbols indicate winter roosting in coniferous stands or hedges.

"winter" peak, however, may be questionable because of the relatively small numbers of birds involved and the late time of the year at which winter roosts were occupied in 1983–84. However, because a winter peak was clearly observable at a roosting site located outside the city (Reebs 1986), I believe the phenomenon to be real and widespread. A second peak was recorded in February of 1984 and March of 1985, involving maxima of 150 and 108 magpies, respectively. In both years, this "spring" peak was followed in late March–early April by a steady decline in numbers. Magpies in Edmonton initiate laying during the last two weeks of April (Hochachka 1985), by which time almost all winter roosts were empty. The only exception occurred at Mill Creek in 1984, where a small flock of 15 individuals (possibly non-breeding yearlings) continued to use one of the roosts until mid-May (Figure 2).

Communal roosting did not appear to be an obligatory activity, as I sometimes saw magpies, in both fall and winter, spending the night singly or in pairs away from regular roosting sites. Those magpies were perching in dense clumps of aspen (fall) or spruce (winter) outside the river valley, and may have been adults roosting on their usual breeding territories (C. Scharf, personal communication).

Behaviour of magpies at the roosts

Magpies went to the roosts throughout the hour preceding sunset. The arrival was gradual, spanning 35–71 min and involving lone birds, pairs, and a few small flocks of up to 30 birds (Reebs 1985). The first birds to arrive at the site usually perched in conspicuous places such as the tops of tall trees, where they were joined by later arrivals. Vocalizations were infrequent. The birds limited their activities to occasional movements from branch to branch and to preening. Exceptions to this quiet type of assembly were sometimes observed at Mill Creek and Whitemud Creek. All birds then flew around the site or moved about noisily at the tops of trees, sometimes chasing one another. This behaviour has also been reported and described for European magpies (Ward 1952). This group display often began suddenly, lasted for up to 20 min, and usually ended at sunset. I witnessed it only during the spring peak or on the first days of mild weather following long spells of cold temperatures.

Around sunset, the birds descended to the roosts. There, single birds appeared not to allow other individuals to roost in the trees they were occupying, or even in neighbouring trees. Likewise I never saw magpies huddling, even when the temperature was as low as -23°C . In contrast, I observed three aggressive interactions in which a magpie chased away another conspecific that had landed in a tree next to it. Such

behaviour resulted in horizontal spacing of magpies throughout the whole roost.

All activity ceased 34–43 min after sunset. At that time, the magpies I could see were always 3–8 m high, on branches 0.5–1.5 cm in diameter, usually preening, scratching, stretching, and fluffing up their feathers. In the conifers they were usually next to the trunk, and most often at the level of the lowest branches bearing needles, immediately below the canopy. The birds apparently did not change place during the night, as any individual seen during the evening was invariably found in the same spot the next morning. The same perches were used repeatedly over successive nights (presumably by the same individuals), as witnessed by a few direct observations and by the very conspicuous piling-up of droppings on some lower branches.

Magpies appeared to be light sleepers and were wary at night. Most remained motionless but alert (neck stretched out, feathers sleek) when I approached them as silently as possible. If I touched their roost trees or turned on a flashlight, all would fly away, sometimes hitting thin branches in the dark. They also often gave one or two alarm calls (*see* Buitron 1984) while in flight.

Before leaving the roosts in the morning, magpies usually gathered again in dead trees or at the tops of tall spruce trees. Departure occurred during the 45 min preceding sunrise. It was more sudden than arrival, spanning 2–23 min and involving large flocks (up to 56 birds) followed by a few smaller flocks and straggling pairs (Reebs 1985). The birds vocalized frequently, especially when the first ones took to the air.

Discussion

Magpies in the present study roosted in dense deciduous thickets in the fall, even remaining in them after leaf fall, but they switched to conifers after the appearance of snow cover and cold ($< -5^{\circ}\text{C}$) temperatures. This suggests that magpies seek the presence of overhead and/or vertical cover when winter conditions prevail. All coniferous roosts had good overhead cover, which can minimize radiative heat loss to clear skies (Morse 1980). The birds' exposure to the sky was probably further minimized by their position immediately below the tree crown. Because most roosts were located on slopes, the overhead cover also acted as vertical cover. This probably contributed to wind reduction. The importance of avoiding wind exposure has been stressed by Mugaas and King (1981), who calculated that at -20°C a magpie could reduce its metabolic demands by as much as 8.3% by opting to spend the night in a dense fir grove where wind speed would be reduced from 14.4 km/h to 1.44 km/h. I observed

similar levels of wind speed reduction in the present study, and given the colder temperatures often experienced in Edmonton throughout the winter, the benefits magpies obtained by roosting in wind-sheltered coniferous stands could have been even more substantial.

Although coniferous hedges were present outside the river valley and appeared suitable for roosting (e.g. Windsor roost), most winter roosts were found within the river valley or its tributary creeks. Such a location has implications for the microclimatology of the roosts. As in many other river valleys, temperatures tend to be colder and winds tend to be weaker in the valley of the North Saskatchewan River than in the rest of the city above it (Klassen 1962; Paterson and Hage 1979). Strong inversions commonly occur at night, and this means that temperatures are often higher near the top of the slopes than near the bottom (see Table 2). Wind reduction shows a reverse trend, being greater near the bottom (see Table 2). At Whitemud Creek, the difference in temperature between top and bottom was rather small (2.3°C on average at night), but the difference in wind reduction was substantial when winds were blowing in the direction the slope was facing (Table 2). By roosting in the middle of the slope at Whitemud 2, the magpies may have been compromising between greatly reduced exposure to wind and slightly lower temperatures. However, magpies also roosted at the top or bottom of slopes in other locations (Table 1). Because of their patchy distribution in the valley, coniferous stands were not always available at all altitudes on the slopes, and this may have limited the birds' choice.

Magpies avoided north-facing slopes, at least within the study site. Because of the permanent lack of exposure to the sun, temperatures on these slopes were probably colder than on east- or west-facing slopes, especially at the end of the day when magpies went to roost.

Although Northern Goshawks (*Accipiter gentilis*) have been known to prey on magpies leaving the roost (Goodwin 1976), nobody has ever reported a case of predation in a roost at night. However, given the opportunity, Great Horned Owls (*Bubo virginianus*) would probably be able to kill magpies (see Buitron 1984). On three occasions, I observed Great Horned Owls present at dusk at two of the roosting sites. The tendency to perch in the midst of a dense network of dead branches and twigs may represent the magpie's defence against such a predator, as it may prove difficult for an owl to fly freely at night within such an environment. The year-round preference of Black-billed Magpies for very dense stands of trees or scrub appears in all references to roosting in this species

(Linsdale 1937; Ward 1952; Goodwin 1976; Gyllin and Källander 1977; Mugaas and King 1981). Such a preference was also found in the present study and was further illustrated by the birds' tendency to perch on the densest side of trees.

The changes in the numbers of roosting birds showed a general increase at the larger roosting site throughout the winter. The cause of an assumed small peak in December is unclear but may be related to as yet unknown parameters of the magpies' ecology in Edmonton, such as the time of brood break-up and dispersal, or winter movements from one feeding ground to another. The spring peak, on the other hand, was concurrent with, and may have been an indirect consequence of, the occurrence of noisy social displays at the roosts. The noisiest displays probably occur at the largest roosts because of the larger number of birds involved, and they may attract individuals from other roosts. Consistent with this idea is the fact that the increase in size at Mill Creek took place concurrently with a decrease in size at two smaller roosts (Mayfair and Windsor; see Figure 2). However, the function of these displays, as well as whether or not they are causally related to roost size, is still unknown.

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Literature Cited

- Buitron, D. 1984. Variability in the responses of Black-billed Magpies to natural predators. *Behaviour* 87: 209-236.
- Cottam, G., and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. *Ecology* 37: 451-460.
- Goodwin, D. 1976. *Crows of the world*. Comstock, Ithaca, New York.
- Gyllin, R., and H. Källander. 1977. Roosting behavior of the Magpie *Picapica*. *Fauna Flora* (Stockholm) 72: 18-24. [In Swedish with English summary].
- Hochachka, W. M. 1985. The effect of food availability on Black-billed Magpie reproduction. M.Sc. thesis, University of Alberta, Edmonton, Alberta. 97 pp.
- Klassen, W. 1962. Micrometeorological observations in the North Saskatchewan River Valley at Edmonton. Meteorological Branch, Canadian Department of Transport, Technical Circular 3652. 16 pp.

- Linsdale, J. M.** 1937. The natural history of magpies. Pacific Coast Avifauna Number 25. Cooper Ornithological Club, Berkeley, California.
- Morse, D. H.** 1980. Behavioral mechanisms in ecology. Harvard University Press, Cambridge, Massachusetts.
- Mugaas, J. N., and J. R. King.** 1981. Annual variation of daily energy expenditures by the Black-billed Magpie: a study of thermal and behavioral energetics. Studies in avian biology Number 5. Allen Press, Lawrence, Kansas.
- Paterson, R. D., and K. D. Hage.** 1979. Micro-meteorological study of an urban valley. Boundary Layer Meteorology 17: 175-186.
- Reebs, S. G.** 1985. Ecological aspects of sleep in Black-billed Magpies. M.Sc. thesis, University of Alberta, Edmonton, Alberta. 86 pp.
- Reebs, S. G.** 1986. Influence of temperature and other factors on the daily roosting times of Black-billed Magpies. Canadian Journal of Zoology 64: 1614-1619.
- Salt, W. R., and J. R. Salt.** 1976. The birds of Alberta. Hurtig Publishers, Edmonton.
- Ward, E.** 1952. Some observations at a Magpie roost. British Birds 45: 403-405.

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A New Shrub for Ontario: Mountain Bilberry, *Vaccinium membranaceum*, in Pukaskwa National Park

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Barclay-Estrup, P. 1987. A new shrub for Ontario: Mountain Bilberry, *Vaccinium membranaceum*, in Pukaskwa National Park. Canadian Field-Naturalist 101 (4): 526-531.

A vegetation survey in Pukaskwa National Park carried out in conjunction with lake, soil, and rock studies resulted in the confirmation of a new shrub species for Ontario. This species, Mountain Bilberry (*Vaccinium membranaceum*), is common in the study area. It is found on shallow acid soils in mature and over-mature mixed forests. It occurs in a sparse to moderately dense shrub layer over a usually well-developed herb layer (possibly a response to severe Spruce Budworm defoliation). Lists of vascular plants, bryophytes, and lichens associated with Mountain Bilberry are included.

Key Words: New species, *Vaccinium membranaceum*, Mountain Bilberry, Ontario, Pukaskwa National Park.

In the course of acid precipitation studies conducted from 1983 to 1985 at eight lake areas in Pukaskwa National Park, a new Ontario shrub was discovered. This new ericaceous shrub, Mountain Bilberry (*Vaccinium membranaceum* Dougl.), was found to be present in large numbers in Pukaskwa. The purposes of this paper are to report this new occurrence and the Pukaskwa locations of Mountain Bilberry, and also to describe some aspects of the Pukaskwa habitat and the associated species.

Mountain Bilberry is a small-to-medium sized shrub (up to 2.0 m in British Columbia, but mostly less than 0.5 m in Pukaskwa) with serrate deciduous leaves. The solitary flowers are in the leaf axils and have awned anthers. These flowers produce sweet blue to black berries. Usually, no infraspecific taxa are recognized. However, Scoggan (1978-79) does divide the species into two varieties, *rigidum* and *membranaceum*. If varieties are used, then the Pukaskwa collections are var. *membranaceum*.

Mountain Bilberry is widely distributed in North America. In Canada it occurs in the southwestern Northwest Territories (Porsild and Cody 1980), western Alberta (Moss 1983) and in much of British Columbia (Szcawinski 1962; Taylor and MacBryde 1977). It also occurs in the northwestern United States as far south as northern California (Jepson 1960). In eastern North America it is found in three counties that border on Lake Superior in the state of Michigan, but neither Fernald (1950) nor Gleason (1963) reports Mountain Bilberry from eastern Canada. Two recent publications, *Shrubs of Ontario* (Soper and Heimbürger 1982) and a checklist of Superior Provincial Park (Anonymous 1985), also do not include Mountain Bilberry.

Records have been made in two localities in Ontario, the Bruce Peninsula and Little Pigeon River, but there is no verifying specimen for the record from the Bruce Peninsula (George Argus, personal communication), and a collection from "Little Pigeon River" near Thunder Bay held by the Harvard University Herbarium is actually *Vaccinium myrtilloides*. The present report, therefore, is the first verified record of Mountain Bilberry in Ontario.

Study Area

Pukaskwa National Park is located on the northeastern shore of Lake Superior (Figure 1). The eight study lakes are inland in the park between Oiseau Bay and Otter Island (Figure 2).

The park has a cool temperate climate with mild summers (July \bar{x} = +16°C) and cold winters (January \bar{x} = -13°C). The climate is humid with an average annual precipitation of 87 cm (about 18 cm is water equivalent of snow). Cloud and fog are relatively common.

The study sites are in an area of rugged topography, mostly at relatively high elevations. The highest lakes are at 435 m; the lowest of the eight lakes (6A-22) is at 310 m (Lake Superior has an elevation of 183 m). The bedrock associated with these lakes is primarily granite with intrusions of pegmatite, prophyry, and diabase. The soils of the areas are classified, using the Canadian system of Soil Classification, as humo-feric podzols.

The vegetation of the park is boreal forest. It is variously classified as strongly Humid Southern Boreal by Ahti (1964), as Boreal Forest Superior Section by Rowe (1972), and as Low Boreal by Zoltai and Pollett (1983). Garton (1976, 1977) produced

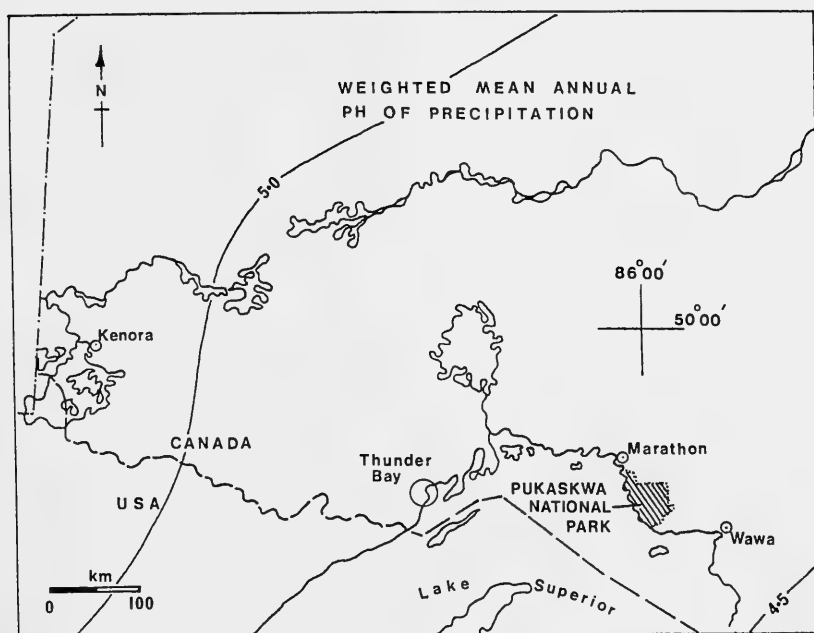


FIGURE 1. Pukaskwa National Park, Ontario, Canada. Isolines of the weighted mean annual pH of precipitation are also included.

check-lists of vegetation found along the Lake Superior coast. A more detailed study of forest types, including a check-list, has been done by Gimbarzevsky et al. (1978).

The study area has not been affected by logging since it is quite inaccessible. The study lakes are situated in areas that tend to be fire-resistant owing to the humid climate, dissected topography, areas of open rock, and many lakes. Alexander (1978, 1980) has described some of the fire history of Pukaskwa. While logging and fire have had little effect on the vegetation of the study areas, Spruce Budworm (*Choristoneura fumifera*) is an important biotic factor. The moderate to severe infestation of Spruce Budworm in the park from 1975 to the present has resulted in considerable modification of the Balsam Fir (*Abies balsamea*) and White Spruce (*Picea glauca*) components of the forest.

Methods

The study area (Figure 1) in Pukaskwa National Park was visited three times: 12 September 1984, 21 May 1985, and 18 June 1985. As the area is remote and the terrain is difficult, transport to the lake study areas was by a float-equipped Bell 206B helicopter. Eight lakes, previously studied for lake and soil characteristics, were visited for vegetation studies.

These were carried out near soil pit study areas. Table 1 has data for the six lake areas where Mountain Bilberry is present. At each soil pit 10-x-10-m areas were marked, the dbh (diameter at breast height) was measured for all tree species, species lists were prepared, and cover estimations were made. General area species lists were also made as time permitted. (Details of these studies are in Barclay and Viitala 1983). Some collections were made of not readily identifiable species. Mountain Bilberry was collected at three lakes: MOE-1 deposited in the Pukaskwa Park Herbarium; LU-8 deposited in the National Herbarium of Canada, and LU-10, retained in the author's personal herbarium.

Nomenclature of vascular plants is according to Scoggan (1978-79); mosses are according to Ireland (1980); liverworts are according to Stotler and Crandell-Stotler (1977); and lichens are according to Hale (1979).

Results

Mountain Bilberry was found at six of the eight lakes visited in Pukaskwa National Park. At five of these locations it is one of the two most dominant shrub species. Therefore, in this area of about 5 X 10 km it can be considered common. The remaining two lakes with no Mountain Bilberry present (MOE-9

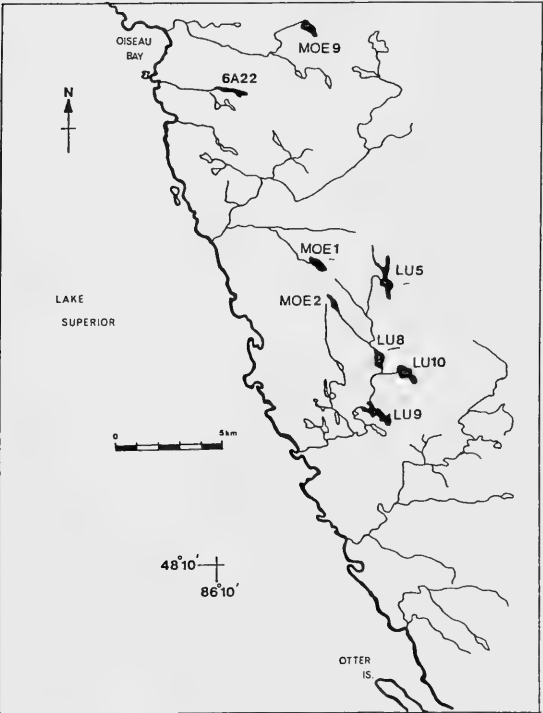


FIGURE 2. Location of the APIOS (Acid Precipitation in Ontario Study) study lakes in Pukaskwa National Park.

and 6A-22) are both north of the other six lakes (Figure 2). They also have significantly different vegetation, as can be shown by single axis polar ordinations (Bray and Curtis 1957). Lake 6A-22 is the only site with a well-developed moss layer which is dominated by *Pleurozium schreberi* and *Dicranum polysetum*. Lake MOE-9 has a mixed forest and is the only one of the eight areas with Trembling Aspen, *Populus tremuloides*.

The six lake areas where Mountain Bilberry occurs (Table 2) have mature and over-mature forests dominated by White Birch (*Betula papyrifera*) and Balsam Fir. Black Spruce (*Picea mariana*), White Spruce and White Cedar (*Thuja occidentalis*) are also common. The shrub layer is sparse to moderately dense and is dominated by Mountain Bilberry and Mountain Juneberry (*Amelanchier bartramiana*). It also often includes Mountain Maple (*Acer spicatum*) and Ground Hemlock (*Taxus canadensis*). There is a well-developed herb and dwarf-shrub layer, which is usually dominated by Bracken (*Pteridium aquilinum*), Canada Bunchberry (*Cornus canadensis*) and

Wild Lily-of-the-valley (*Maianthemum canadense*). Bryophytes and lichens are mostly restricted to old wood and boulders. Important species in this layer are *Pleurozium schreberi*, various *Dicranum* spp., *Ptilidium pulcherrimum*, and several species of *Cladonia*.

At five of the Mountain Bilberry lakes there is obvious and significant Balsam Fir mortality as the result of defoliation by Spruce Budworm. the ecosystem has responded with a very well-developed herb and dwarf-shrub layer and considerable regeneration, especially of Balsam Fir and White Cedar. This endemic insect may play a significant role in forest cycling systems and may thereby affect all the vegetation, including Mountain Bilberry.

Discussion

This report and the collected specimens establish Mountain Bilberry as part of the shrub flora of eastern Canada. There is, however, no special biogeographical significance to this new record. Mountain Bilberry joins the list of species which are widely distributed in western Canada but which have disjunct and much smaller populations in eastern Canada, such as Giant Rattlesnake Plantain (*Goodyera oblongifolia*), Thimbleberry (*Rubus parviflorus*), Devil's Club (*Oplopanax horridum*), and Oval-leaved Bilberry (*Vaccinium ovalifolium*). In Ontario all these species, including Mountain Bilberry, are primarily found in the cool humid region that occurs close to the upper Great Lakes.

There are no specific studies of the ecology of Mountain Bilberry in western Canada (R. Ogilvie and T. C. Brayshaw, personal communication). However, a number of Land Management Reports have been published by the British Columbia Ministry of Forests (eg. Haeussler et al. 1984). Several of these reports give ecological information about Mountain Bilberry. This information shows that Mountain Bilberry has a broad ecological amplitude in British Columbia. Generally, it is found in most higher elevation forests except the wettest outer coastal region and the driest interior regions: It is found on soils that vary from oligotrophic to sub-minerotrophic.

The sub-alpine forests of central and northern British Columbia have many similarities with the cool humid oligotrophic mature and over-mature mixed forests of Pukaskwa Park that are the Ontario habitats of Mountain Bilberry. The presence of Mountain Bilberry in these two widely separated locations would tend to indicate, perhaps, that these now separate populations were, as has been often suggested, part of a larger single population in the past.

TABLE 1. Location and soil information for the six Pukaskwa Lake areas where Mountain Bilberry is present. The pH of the soil is taken in a 1:1 ratio of water to soil by weight. CEC is cation exchange capacity in me/100 g and is expressed at a pH of 4.5.

Name	Elevation in metres	Latitude 48° minutes	Longitude 86° minutes	Soil Horizons			
				Organic (LFH)		Mineral (A)	
				pH	CEC	pH	CEC
LU-5	435	17'	03'	3.5	17.0	4.6	1.4
LU-8	370	15'	03'	4.3	19.0	4.8	1.8
LU-9	335	13'	03'	4.1	20.0	4.6	1.6
LU-10	380	15'	02'	3.7	20.0	4.7	1.6
MOE-1	435	18'	05'	3.9	23.0	4.5	4.3
MOE-2	420	16'	05'	3.7	21.0	4.4	4.7
Mean	396	-	-	3.9	20.0	4.6	2.6

TABLE 2. Presence of vascular, bryophyte and lichen species in the Mountain Bilberry sites. The two most dominant vascular species for each strata are marked D. The presence of all other species is marked by an X. All species are listed in most common to least common order. * = most trees dead due to Spruce Budworm.

Study Site	LU-8	LU-5	MOE-1	MOE-2	LU-9	LU-10	Total
Trees (8)							
<i>Betula papyrifera</i>	D	D	X	D	D	D	6
<i>Abies balsamea</i>	D*	D*	D*	X*	X*	D	6
<i>Picea mariana</i>	X	X	X	D	X	X	6
<i>Thuja occidentalis</i>	X	X	D	X	D		5
<i>Sorbus decora</i>	X	X	X	X	X		5
<i>Picea glauca</i>	X	X			X	X	4
<i>Acer rubrum</i>					X		1
<i>Pinus strobus</i>			X				
Shrubs (10)							
<i>Amelanchier bartramiana</i>	X	D	D	D	D	D	6
<i>Vaccinium membranaceum</i>	X	D	D	D	D	D	6
<i>Taxus canadensis</i>	X	X	X	X	X		5
<i>Acer spicatum</i>	D		X	X		X	4
<i>Vaccinium angustifolium</i>	X				X	X	3
<i>Vaccinium myrtilloides</i>	D			X			2
<i>Diervilla lonicera</i>	X						1
<i>Corylus cornuta</i>	X						1
<i>Prunus virginiana</i>	X						1
<i>Sorbus americana</i>	X						1
Herbs and Dwarf Shrubs (21)							
<i>Clintonia borealis</i>	X	X	D	X	X	X	6
<i>Cornus canadensis</i>	D	X	D	D	X	X	6
<i>Coptis groenlandica</i>	X	X	X	X	X	X	6
<i>Dryopteris austriaca</i>	X	X	X	X	X	X	6
<i>Lycopodium annotinum</i>	X	X	X	X	X	X	6
<i>Maianthemum canadense</i>	X	X	X	D	D	D	6
<i>Pteridium aquilinum</i>	D	D	X	X	D	D	6
<i>Aralia nudicaulis</i>	X		X	X	X	X	5
<i>Gaultheria hispida</i>	X	X	X	X			4
<i>Lycopodium obscurum</i>	X	X			X	X	4
<i>Osmunda claytoniana</i>	X	X			X	X	4
<i>Cypripedium acaule</i>	X	X	X				3
<i>Linnaea borealis</i>	X	X				X	3

(continued)

TABLE 2. Continued

Study Site	LU-8	LU-5	MOE-1	MOE-2	LU-9	LU-10	Total
<i>Epigaea repens</i>		X			X		2
<i>Goodyera oblongifolia</i>			X		X		2
<i>Lycopodium clavatum</i>	X		X				2
<i>Lycopodium lucidulum</i>		D			X		2
<i>Carex arctata</i>	X						1
<i>Lycopodium complanatum</i>						X	1
<i>Streptopus amplexifolius</i>	X						1
<i>Streptopus roseus</i>					X		1
Mosses (18)							
<i>Dicranum montanum</i>	X	X	X	X	X	X	6
<i>Dicranum scoparium</i>	X	X	X	X	X	X	6
<i>Drepanocladus uncinatus</i>	X	X	X	X	X	X	6
<i>Pleurozium schreberi</i>	X	X	X	X	X	X	6
<i>Dicranum ontariense</i>	X	X	X	X		X	5
<i>Pogonatum alpinum</i>	X		X	X	X	X	5
<i>Plagiothecium laetum</i>	X	X	X		X	X	5
<i>Ptilium crista-castrensis</i>		X	X	X	X	X	5
<i>Pohlia nutans</i>	X	X	X	X			4
<i>Polytrichum juniperinum</i>	X		X		X	X	4
<i>Brachythecium reflexum</i>	X	X					2
<i>Hylocomium splendens</i>				X	X		2
<i>Hylocomium umbratum</i>		X			X		2
<i>Pylaisiadelphus recurvans</i>		X		X			2
<i>Brachythecium curtum</i>					X		1
<i>Brachythecium</i> sp.	X						1
<i>Dicranum polysetum</i>			X				1
<i>Sphagnum russowii</i>		X					1
Liverworts (8)							
<i>Ptilidium pulcherrimum</i>	X	X	X	X	X	X	6
<i>Barbilophozia attenuata</i>	X	X	X		X	X	5
<i>Blepharostoma trichophyllum</i>		X	X		X	X	4
<i>Barbilophozia hatcheri</i>	X	X					2
<i>Bazzania trilobata</i>		X			X		2
<i>Cephalozia lunulifolia</i>					X		1
<i>Jamesoniella autumnalis</i>		X					1
<i>Lophozia prophyroleuca</i>		X					1
Lichens (11)							
<i>Cladonia coniocraea</i>	X	X	X	X	X	X	6
<i>Cladonia chlorophaea</i>	X	X	X	X	X	X	6
<i>Cladonia squamosa</i>	X		X		X		3
<i>Cetraria pinastri</i>	X	X		X			3
<i>Cladonia rangiferina</i>	X		X	X			3
<i>Cladonia cenotea</i>		X		X			2
<i>Cladonia phyllophora</i>	X					X	2
<i>Cladonia conista</i>			X				1
<i>Hypogymnia physodes</i>	X						1
<i>Lecidea berengeriana</i>	X						1
<i>Peltigera aphthosa</i>					X		1
Total species = 76							
Total species per study site	54	46	41	35	45	35	

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Literature Cited

- Ahti, T.** 1964. Macrolichens and their zonal distribution in boreal and arctic Ontario, Canada. *Annals Botanica Fennica* 1: 1-35.
- Alexander, M. E.** 1978. Reconstructing the fire history of Pukaskwa National Park. *In* Fire ecology in resource management workshop proceedings, December 1977. Canadian Forestry Service Information Report NOR-X-210. Edmonton.
- Alexander, M. E.** 1980. Forest fire history research in Ontario: a problem analysis. *In* Proceedings of the fire history workshop, October 1980. Forest Service, U.S. Department of Agricultural General Technical Report RM-81. Fort Collins, Colorado.
- Anonymous.** 1985. Checklist of the plants of Lake Superior Provincial Park, Government of Ontario, Wawa, Ontario.
- Barclay, P., and R. L. Viitala.** 1985. The vegetation near some acid stressed lakes in Pukaskwa National Park, Ontario. Lakehead University, Thunder Bay, Ontario.
- Bray, J. R., and J. T. Curtis.** 1957. An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs* 27: 325-349.
- Fernald, M. L.** 1950. Gray's manual of botany. Eighth edition. American Book Company, New York.
- Garton, C. E.** 1976. Botanical investigation of Pukaskwa National Park. Lakehead University, Thunder Bay, Ontario.
- Garton, C. E.** 1977. Botanical investigations of Pukaskwa National Park 1974-1977. Lakehead University, Thunder Bay, Ontario.
- Gimbarzevsky, P., N. Loupoukhine, and P. Addison.** 1978. Biophysical resources of Pukaskwa National Park. Information Report FMR-X-106, Forest Management Institute, Environment Canada, Ottawa.
- Gleason, H. A.** 1963. The new Britton and Brown illustrated flora of the northeastern United States and adjacent Canada. Three volumes. Hafner Publishing Company, New York.
- Haeussler, S., J. Bojar, B. M. Geisler, D. Yole, and R. M. Annas.** 1984. A guide to the coastal Western Hemlock zone, northern drier maritime subzone (CWHF), in the Prince Rupert Forest Region, British Columbia. Land Management Report Number 21, British Columbia Ministry of Forests. Victoria, British Columbia.
- Hale, M. E.** 1979. How to know the lichens. Second edition. W. C. M. Brown Company, Dubuque, Iowa.
- Ireland, R. R., C. D. Bird, G. R. Brassard, W. B. Schofield, and D. H. Vitt.** 1980. Checklist of the mosses of Canada. Publications in Botany Number 8. National Museums of Canada. Ottawa.
- Jepson, W. L.** 1960. A Manual of the flowering plants of California. University of California Press, Berkeley, California.
- Moss, E. H.** 1983. Flora of Alberta. Second edition, revised by J. G. Packer. University of Toronto Press, Toronto, Ontario.
- Porsild, A. E., and W. J. Cody.** 1980. Vascular plants of the continental Northwest Territories, Canada. National Museums of Canada. Ottawa.
- Rowe, J. S.** 1972. Forest regions of Canada. Canadian Forestry Service, Environment Canada Publication Number 1300. Ottawa.
- Scoggan, H. J.** 1978-79. The flora of Canada. Four volumes. National Museums of Canada. Ottawa.
- Soper, J. H., and M. L. Heimbürger.** 1982. Shrubs of Ontario. Royal Ontario Museum. Toronto, Ontario.
- Stotler, R., and B. Crandall-Stotler.** 1977. A checklist of the liverworts and hornworts of North America. *The Bryologist* 80: 405-428.
- Szczawinski, A. F.** 1962. The heather family (Ericaceae) of British Columbia. British Columbia Provincial Museum. Victoria, British Columbia.
- Taylor, R. L., and B. MacBryde.** 1977. Vascular plants of British Columbia. University of British Columbia, Vancouver, British Columbia.
- Zoltai, S. C., and F. C. Pollett.** 1983. Wetlands in Canada: their classification, distribution, and use. *In* Mires: Swamp, Bog, Fen and Moor. Edited by A. J. P. Gore, Elsevier Publishing Company, Amsterdam.

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Shumard Oak, *Quercus shumardii*, in Canada*

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Shumard Oak (*Quercus shumardii* Buckl.), a tree primarily of the east-central United States, is confirmed to be present in four counties of southwestern Ontario. This represents a 150-km northward extension of the previously recognized range of the species. Taxonomic confusion has surrounded the species for over a century. It has been designated rare nationally because of its limited distribution. It is afforded some protection by its presence in several conservation areas and parks, and is able to regenerate naturally. Because of its desirability as an ornamental shade tree, it has been planted in some urban areas.

Key Words: Shumard Oak, *Quercus shumardii*, new plant records, Ontario.

No indisputable collections of Shumard Oak (*Quercus shumardii* Buckl.), made prior to 1978 can be found in major Ontario herbaria. Since that time, collections of this species have been made in extreme southwestern Ontario, as well as in the eastern Niagara peninsula.

Species in the oak subgenus *Erythrobalanus* (Red and Black oaks) have proven difficult to naturalist and oak specialist alike. An examination of herbarium specimens misnamed or variously interpreted, leaves no doubt as to the confusion which exists. It is likely because of this confusion that the group is so poorly represented in herbaria.

Persistent references to Scarlet Oak (*Q. coccinea* Muenchh.) in southern Ontario are found in the literature (Macoun 1883–86; Soper 1949; Anonymous 1949), and oaks with large, seven-lobed leaves with deep, rounded sinuses and with large acorns have been confusing observers in southwestern Ontario for many years (W. Balkwill, W. Botham, W. Morsink, personal communications). Some of these are referable to Black Oak, (*Q. velutina* Lam.; Table 1) or to Hill's Oak (*Q. ellipsoidal* E. J. Hill; Maycock et al. 1980; Ball 1981). Others can be referred to *Q. shumardii*. Fox and Soper (1954) concluded that reports of Scarlet Oak in southern Ontario are the result of confusion with Red Oak, (*Q. rubra* L.), Pin Oak, (*Q. palustris* Muenchh.) and Black Oak, but did not consider the possibility of confusion with Hill's or Shumard oak.

Description

Shumard Oak is a large tree. It reaches heights of 40 m in the southern portion of its range (Moore 1950; Vines 1953), with massive limbs and an open, wide-spreading crown. The trunk of older specimens is heavily buttressed and covered with dark grey, furrowed bark. The bark ridges are broken, rather than continuous as in Red Oak (Steyermark 1963). Bark on younger limbs is smooth and light grey. The reddish or greyish brown twigs are soon glabrescent. Buds are oval, pointed and typically slightly grey pubescent. Leaves are oblong or obovate, smooth and deeply sinuate-pinnatifid with broad convergent sinuses. The five to nine leaf lobes have three or more teeth that are sharply and setaceous acute. There are often conspicuous tufts of stellate hairs in the abaxial vein axils.

The acorns (Figure 1) are large, approximately 2.5 cm long, ovoid and shallowly enclosed in a flat-topped or slightly turbinate, grey cup of closely imbricate, minutely pubescent scales (Braun 1969; Buckley 1861; Deam 1953; Hough 1907; Palmer 1942; Rehder 1940). Many authors have noted that the fall colour of this species is either a rich, vinous red, nearly as brilliant as Scarlet Oak, or remains green longer than adjacent oaks of other species. The foliage is persistent into winter, similar to Hill's Oak and Pin Oak.

Although Shumard Oak has been called a botanist's species, it is no more difficult to recognize than other oaks of the Red and Black oak group. Confusion arises in this group because of extensive hybridization (Jensen 1977; Morsink and Pratt 1984; Palmer 1942), and more fundamentally because of difficulties with the classical species concept of a morphologically defined species (Burger 1975). As a result of this confusion, Shumard Oak has generally received little attention. In contrast, Scarlet Oak, one of the first

*Based on a COSEWIC status report by G.E.W. Copies of the complete report are available at cost from the Canadian Nature Federation, 453 Sussex Drive, Ottawa, Ontario K1N 6Z4. Rare status approved and assigned by COSEWIC on 4 April 1984.

TABLE 1. Herbarium specimens, initially identified as *Quercus coccinea* that are referable to *Q. velutina*.

TRT 9180	<i>Q. coccinea</i> , coll. Wm. Scott, May 16, 1896; det. J. Macoun; annotated <i>Q. velutina</i> , P. V. Krotkov, 1940.
TRT 91979	<i>Q. coccinea</i> , coll. J. H. Soper and H. M. Dale, Aug 15, 1948; det. J. K. Shields; annotated <i>Q. velutina</i> , J. H. Soper, 1954.

American oaks to attract popular attention, has been credited with a range far beyond its actual limits (Gibson 1913; Palmer 1942). Thus we find Macoun (1883-1886) giving the range of Scarlet Oak up to the Toronto area and "more numerous to the west and in the forest along the Niagara River and Lake Erie".

In Ontario, Shumard Oak can be confused with the following oaks: Red, Pin, Hill's, and Black. Typical specimens of Shumard Oak can be separated from the above oaks with just a few characters. Hill's and Black oak are characteristically trees of well-drained, usually coarse-textured soils. Shumard Oak grows on moist soils of fine texture. Pin and often Hill's oak have descending lower branches in contrast to the massive, ascending branches of Shumard Oak. Pin, Hill's and Black oaks have small acorns 1.5 cm or less

in length. Shumard Oak, on the other hand, is similar to Red Oak in having large acorns about 2.5 cm long (Figure 1). It is, however, separated from Red Oak by its lustrous leaves with deep, rounded sinuses and conspicuous, axillary tufts of hair on the lower leaf surface. Red Oak leaves tend to be dull, and the sinuses narrow, shallow and without conspicuous, axillary tufts. Scales on the acorn cup of Shumard Oak are usually grey tomentose versus the shiny, glabrous scales of Red Oak.

The first published description of what is now called *Q. shumardii* was by Torrey (1859), who recognized the taxon as *Q. coccinea* var. *microcarpa*. Earlier collections by Engelmann from the St. Louis, Missouri, area appear in his herbarium as *Q. rubra coccinifolia*, *Q. n. sp.* or *Q. ambigua*. Engelmann (in Sargent 1894) did not publish a varietal name for these trees. Under published remarks on *Quercus rubra*, a species which he considered one of the most variable of the eastern oaks, he noted a form with "leaves similar to those of *coccinea*, with divaricate, pinnatifid lobes or with leaves smaller and more deeply divided with fewer lobes, much like those of *palustris* and acorns always smaller than in the typical *rubra* and the cup rather deeper". Sargent (1894) reported that specimens from Texas were called *Q. palustris* by Torrey and Gray (1857) and Coulter (1894).

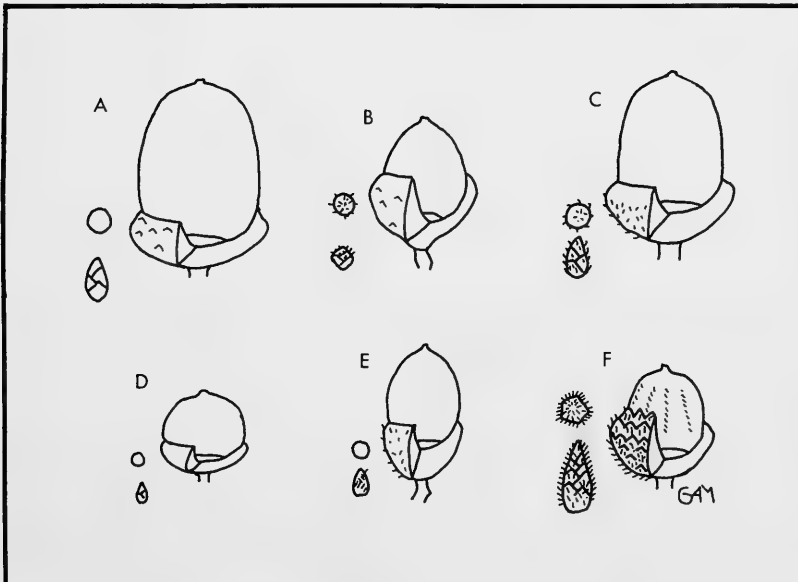


FIGURE 1. Fruits and terminal buds (distal end and side view) of *Quercus* section *Erythrobalanus*, native to northeastern North America, 0.75X. (A) *Q. rubra*; (B) *Q. coccinea*; (C) *Q. shumardii*; (D) *Q. palustris*; (E) *Q. ellipsoidalis*; (F) *Q. velutina*. Note that C, E and F have caps that are pubescent to some degree, whereas A, B and D have smooth or shiny caps.

Quercus shumardii was first described as a species by S. B. Buckley (1861). In that paper Buckley also described the species *Q. texana*, which in a later paper (Buckley 1881) he reclassified as *Q. rubra* var. *texana*. In reading these two papers, it becomes obvious, as Palmer (1942) has noted, that Buckley "did not clearly understand the difference in range and characters between the two (*Q. rubra* and *Q. rubra* var. *texana*) or between them and his own *Q. shumardii*". Except for slight differences in the number of leaf teeth, size of acorn and tree height, the descriptions of *Q. shumardii* and *Q. texana* are nearly identical.

Although Buckley's description of *Q. shumardii* precedes his description of *Q. texana*, and although it is the only species of the two given a range (upper Louisiana, eastern and middle Texas), C.S. Sargent (1894, 1895) used *texana* Buckl. in extending the known range of the species from Texas to "northeastern Iowa and central Illinois through southern Illinois and Indiana and western Kentucky and Tennessee, to the valley of the Appalachicola River in Florida, and through southern Missouri, Arkansas and Louisiana". Although he was aware of Torrey's 1859 description, Sargent did not use the epithet *microcarpa* because it was used prior to 1859 by Liebmann for a Mexican species of oak.

It is possible that Sargent did not use the epithet *shumardii* because he was influenced by Buckley's 1881 paper that did not mention *Q. shumardii*. Sometime before 1918, Sargent realized his error. In "Notes on North American Trees" Sargent (1918) described *Q. texana* Sarg. with the notation "Silva N. Am. 8:129 (in part) 1895 (not Buckley)". He further proposed the synonymy between *Q. schneckii* Britt. (Britton 1901) and *Q. texana* Sarg., and suggested that both be included with *Q. shumardii* var. *schneckii* (Britt.) Sarg. In the same publication, Sargent included *Q. rubra* var. *texana* (Buckl.) Buckl. under *Q. shumardii* Buckl.

Inexplicably, he retained *Q. texana* Buckl. (despite this being a synonym of *Q. rubra* var. *texana* (Buckl.) Buckl.) for the shrubs and small trees in the central and west Texas portions of the range. The only justification Sargent could have was the slightly smaller dimensions given by Buckley for *Q. texana* in the original 1860 descriptions. Buckley's *Q. texana* was described as being a tree 60-70 feet high with acorns 1 inch long, whereas *Q. shumardii* was given a height of 70-80 feet, with acorns 1-1½ inches long. The 1918 *Q. texana* Buckl. of Sargent is no more than 30 feet in height with acorns ¼ to ¾ inches long.

In his publication, *Manual of the Trees of North America*, Sargent (1922) retained *Q. texana* Buckl. for the smaller Texas trees and removed *Q. rubra* var. *texana* (Buckl.) Buckl. from synonymy with *Q.*

shumardii Buckl. Under *Q. shumardii* Buckl. he made the notation "*Q. texana* Sarg., in part, not Buckl."

Other workers have either made *Q. texana* Buckl. a variety of *Q. shumardii* (Ashe 1918; Palmer 1942) or kept the two as separate species (Rehder 1940). *Quercus shumardii* var. *texana* (Buckl.) Ashe does not occur in the northern part of the range, being confined to the Edwards plateau of south-central Texas and the canyons and mountains farther west. In addition to the typical variety, most authorities now also recognize *Q. shumardii* var. *schneckii* (Britt.) Sarg. (originally given specific status by Britton 1901).

Variety *shumardii* has a shallow acorn cup of tuberculate scales covering about a fourth of the nut; var. *schneckii* has a deeper cup with thin scales covering about a third of the nut. Acorns of var. *schneckii* are generally also smaller and the differences between sun and shade leaves are not as pronounced, nor the bark as deeply ridged as in var. *shumardii*. The two varieties are found together in the northern part of the range (Braun 1969; Deam 1953). Palmer (1942), however, considered all the northern trees to be variants of var. *schneckii*, reserving var. *shumardii* for trees of the Atlantic coastal plain and deep south, even while noting that northern individuals could be found with flat, shallow cups of tuberculate scales. Collections in Ontario made by the authors resemble both varieties (Table 2).

Distribution in North America

Little (1971) gives the range of this species as the Mississippi and Ohio river basins and the Atlantic coastal plain up to Virginia and westward into central Texas (Figure 2). The most northerly extension occurs up the Wabash River into northeastern Indiana and western Ohio. Outliers are shown up to southern Pennsylvania and southern Michigan. It has not been included in most Michigan floras (Otis 1931; Barnes and Wagner 1981; Voss 1985). We have seen no convincing specimens of *Q. shumardii* from Michigan collected before 1985. Although it was included in the Flora of Kalamazoo County, Michigan, by Hanes (1947) with the description "rare, east side of Austin Lake", Voss (1985) states "such trees seem more likely to be a form of *Q. rubra* or a hybrid involving that species". Sargent (1922) includes southeastern Michigan within the range, giving the following location: "near Portage Lake, Jackson Co." Recent collections (*Waldron, 19,20 MICH*) have been made in Monroe County, Michigan. Deam's (1953) range map for Indiana and Braun's (1969) for Ohio are in agreement with Little's map.

Distribution and Ecology of *Q. shumardii* in Southern Ontario

In Canada, Shumard Oak is confined to the extreme southwestern counties and the northeastern

TABLE 2. *Quercus shumardii* collections in Ontario (1979-1985). Specimens deposited in the herbaria of the National Museum of Natural Sciences (CAN) and the Arboretum, University of Guelph (OACA). The locations are mapped on Figure 2.

Location / Habitat	Habit	Collector Collection No.	Collection Date
Essex County			
1 Anderdon Tp., lot 12, conc. III, fence row	stump sprouts	G. Waldron 2	23 October 1982
2 Anderdon Tp., Texas Rd., UTM 17 3323 45654 (map 40 J/3), roadside, clay	tree 89 cm dbh; one other nearby	J. Ambrose 2977	13 October 1982
3 Colchester N. Tp., lot 16, conc. VII, open grazed woods.		G. Waldron 3	19 June 1982
Colchester N. Tp., lot 33, south conc., Arner town line, farmyard.	large, relic tree	G. Waldron 4	31 August 1982
5 Colchester N. Tp., 2.6 km ESE Paquette Corners, backyard of dwelling, UTM 17 3400 46707 (map 40 J/2).	large, relic tree, 20 m high, 64 cm dbh, locally scarce	S. Aboud 631 J. Ambrose 2644	2 October 1979 10 October 1980
6 Colchester S. Tp., lot 12, conc V, side of drain.	tree 15 m high	G. Waldron 5	12 October 1982
7 Maidstone Tp., lot 18, conc III, clay.		G. Waldron 6	23 October 1982
8 Maidstone Tp., Maidstone Township Central Conservation Area, along trail, UTM 17 3520 46747 (map 40 J/2), wet woods.	tree 92 cm dbh; other similar trees nearby	J. Ambrose 2765	5 October 1982
9 Malden Tp., UTM 17 3341 46580 (map 40 J/3), open field near CKLW radio towers, clay loam.	large tree; smaller trees nearby	J. Ambrose 2978	13 October 1982
10 Malden Tp., lot 66, conc VII.	tree 25 m high	G. Waldron 7	5 October 1980
11 Mersea Tp., lot 226, south conc., UTM 17 3743 46568 (map 40 J/2), Brookston clay-sandspot phase.		G. Waldron 14	6 November 1985
12 Sandwich S. Tp., 0.75 km ENE Paquette Corners, UTM 17 3388 46722 (map 40 J/2).	tree 28 m high, 70 cm dbh	S. Aboud 646	2 October 1979
13 Sandwich S. Tp., lot 17, conc. XI	tree 20 m high	G. Waldron 8	22 October 1982
14 Sandwich S. Tp., lot 226, conc. III, UTM 17 3418 46829 (map 40 J/7), fencerow, Brookston clay.		G. Waldron 15	28 October 1985
15 Tilbury W. Tp., lot 10, conc. VII.	tree 19 m high	G. Waldron 10	20 October 1982
16 Windsor, Devonwood Conservation Area, UTM 17 3365 46807 (map 40 J/7), moist woods.	tree 18 m high, 56 cm dbh.	J. Ambrose 2639	10 October 1980
Kent County			
17 Harwich Tp., lot 26, conc. III, Wilson Conservation Area, shrubby woods.		G. Waldron 11	25 September 1983
Niagara Region			
18 Niagara Tp., 1.6 km NE of St. Davids, UTM 17 6551 47809 (map 30 M/3), moist woods.		G. Meyers A	2 October 1983
19 Niagara Tp., 1.4 km NE of St. Davids, UTM 17 6549 47808 (map 30 M/3).	double-trunked tree, 17 m high; locally common	S. Aboud 1167	26 September 1983
Lambton County			
20 Dawn Tp., lot 27, conc. VII, UTM 17 4079 47304 (map 40 J/9), fence row, level, clay soil.		G. Waldron 16	24 October 1985
21 Enniskillen Tp., lot 18, conc. I, UTM 17 4095 47353 (map 40 J/16), edge of woods, flat, clay soil.	locally frequent	G. Waldron 17	24 October 1985
22 Enniskillen Tp., lot 22, conc. IV, UTM 17 4117 47389 (map 40 J/16), roadside, flat, clay soil.		G. Waldron 18	24 October 1985
23 Sombra Tp., lot 22, conc. XV, UTM 17 3931 47351 (map 40 J/16), fence row, level, clay soil.		G. Waldron 13	24 October 1985

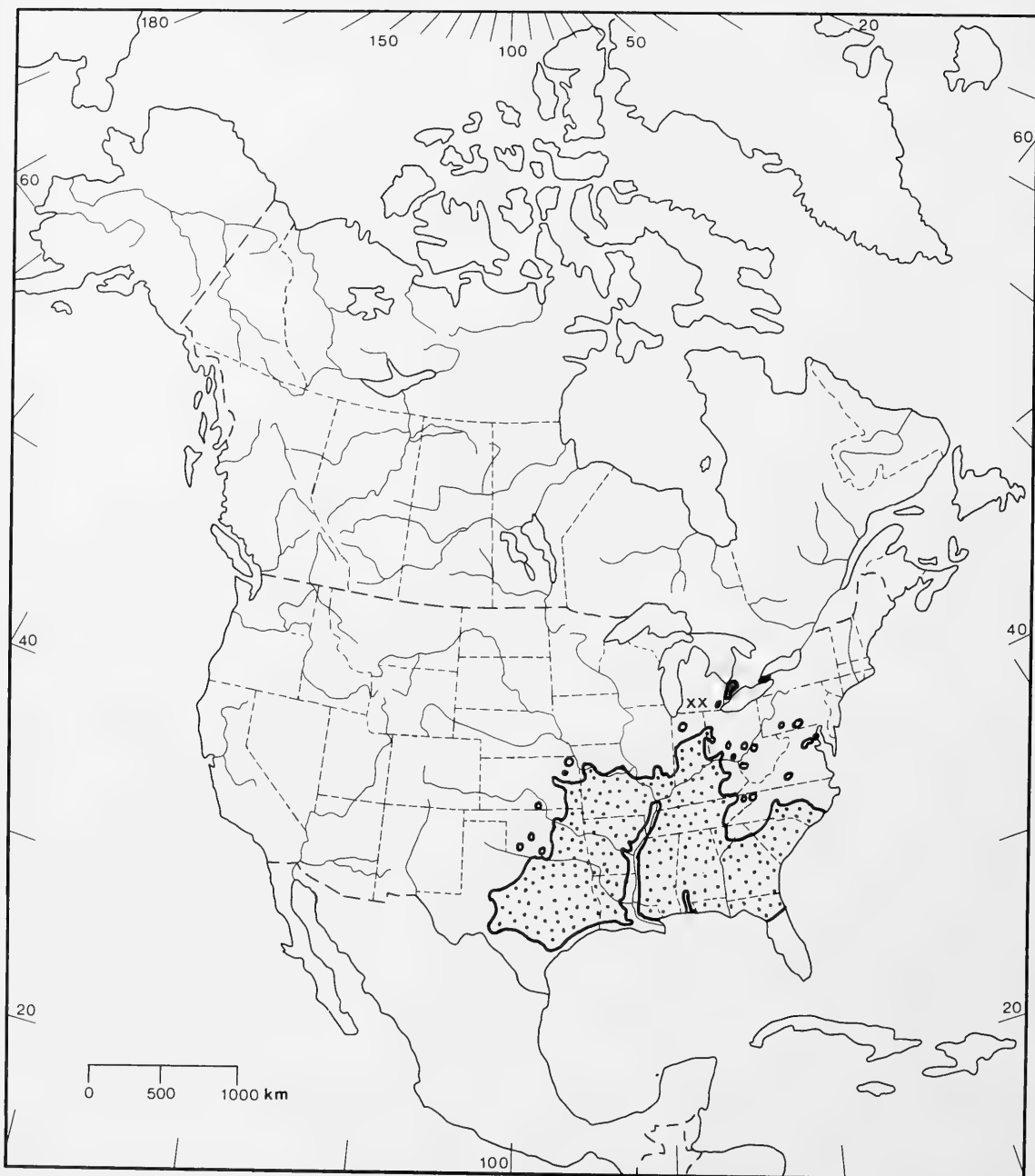


FIGURE 2. The natural distribution of *Quercus shumardii* (after Little (1971)). The new records for Ontario and Michigan discussed in the text are represented by dots or solid areas. The two collections previously recorded for southwestern Michigan are no longer considered to be this species, and are represented by the symbol (x).

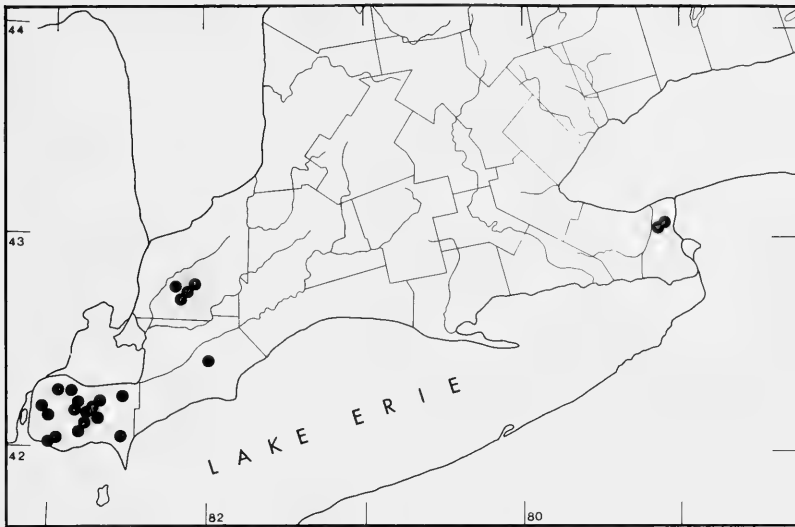


FIGURE 3. Ontario distribution of *Quercus shumardii*, based on collections made by the authors (deposited at CAN and OACA).

Niagara region of Ontario (Figure 3, Table 2). Thus far it has not been found outside the counties of Essex, Kent, Lambton and Lincoln (Regional Municipality of Niagara). The Lincoln County trees are apparently disjunct from closest known population in southern Pennsylvania by 365 km, and from the trees in southwestern Ontario by 225 km.

The range of Ontario Shumard Oak is entirely within the Deciduous Forest Region (Rowe 1972). It is usually a minor associate of, but occasionally codominant with, Black Maple (*Acer saccharum* subsp. *nigrum*), Silver Maple (*A. saccharinum*), Shagbark Hickory (*Carya ovata*), Bitternut Hickory (*C. cordiformis*), Shellbark Hickory (*C. laciniata*), Red Ash (*Fraxinus pennsylvanica*), Sycamore (*Platanus occidentalis*), Eastern Cottonwood (*Populus deltoides*), Swamp White Oak (*Quercus bicolor*), Bur Oak (*Q. macrocarpa*), Pin Oak (*Q. palustris*), Red Oak (*Q. rubra*), Basswood (*Tilia americana*), White Elm (*Ulmus americana*) and Red Elm (*U. rubra*).

In the Shumard Oak's restricted range within Ontario, it was observed on mesic-hydric sites with clays and clay loams of the Brookston, Perth, Toledo and Lincoln soil series. All four soils are characterized by poor internal drainage. These same soil types are found in the Michigan, Indiana and Ohio portions of the Shumard Oak range (Deam 1940; Vannorsdall 1958). Mesic and hydric sites are typical over most of its range (Lotti 1965). Soils in the Ontario portion of the range are rich in all nutrients except phosphorus (Richards et al. 1949). The land is nearly level and

between 75 m and 200 m in elevation. Precipitation is evenly distributed throughout the year with 762–787 mm of rain and 89–114 cm of snow (Brown et al. 1980).

Woodlots in the Canadian range of Shumard Oak are usually highly disturbed. All four counties rank among the highest for proportion of land cleared for agriculture, industry and urbanization. Essex county, where the species appears to be most common, has less than 3% of its original forested area intact (Anonymous 1975): one mainly agricultural township of 9650 hectares has less than 0.2% forest cover remaining (Oldham 1983). Disturbance in the remaining forest includes summer browsing by cattle and horses, periodic logging, clearing for recreational and home sites, ditching and channelization, frequent windstorms and occasional ice storms and tornadoes. Many of these are not negative factors in the survival of the species because oaks reproduce well on open, disturbed sites, but not under closed canopies. The ability of Shumard Oak to sprout from the stump results in its persistence in fence rows that are periodically brushed (Lotti 1965).

Drainage is likely having only a local effect. Agricultural land on the clay and clay-loam soils requires underdrainage at 10-m spacings to significantly alter the soil water regime. Thus, ditching and channelizing will have a greater affect on surface water than on soil water. The greatest effect of drainage may be to increase the numbers of hybrids of Shumard Oak with oak species associated with more xeric sites (Black and Red oaks) and more hydric sites

(Pin Oak). Certainly, hybrids with Shumard Oak in their background are frequent in Essex, Kent (Morsink and Pratt 1984) and Lincoln (Meyers 1984) counties.

The species is sufficiently attractive to have been taken into cultivation. In one block of residential area of Windsor, five young trees were seen growing as shade trees.

Shumard Oak is presently designated rare in Canada by the Committee on the Status of Endangered Wildlife of Canada because of its restricted range.

Acknowledgments

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Literature Cited

- Anonymous.** 1949. Native trees of Canada. Department of Mines and Resources Bulletin 61. Fourth edition. Ottawa.
- Anonymous.** 1975. Essex region conservation report. Essex Region Conservation Authority, Essex, Ontario.
- Ashe, W. W.** 1918. Notes on trees. Proceedings of the Society of American Foresters 11: 40.
- Ball, P. W.** 1981. Hill's Oak (*Quercus ellipsoidalis*) in southern Ontario. Canadian Field-Naturalist 95(3): 281-286.
- Barnes, B. V., and W. H. Wagner.** 1981. A guide to the trees of Michigan. University of Michigan Press, Ann Arbor, Michigan.
- Braun, E. L.** 1969. The woody plants of Ohio. Ohio State University Press, Columbus, Ohio.
- Britton, N. L.** 1901. Manual of the flora of the northern states and Canada. Henry Holt and Company, New York. 333 pp.
- Brown, D. M., G. A. McKay, and L. J. Chapman.** 1980. The climate of southern Ontario. Climatological Studies No. 5. Environment Canada, Ottawa.
- Buckley, S. B.** 1861. Description of several new species of plants. Proceedings of the Academy of Natural Sciences of Philadelphia 1860: 444-445.
- Buckley, S. B.** 1881. *Quercus rubra* var. *texana*. Proceedings of the Academy of Natural Sciences of Philadelphia 1880: 123-124.
- Burger, W. C.** 1975. The species concept in *Quercus*. Taxon 24(1): 45-50.
- Coulter, J. M.** 1894. Manual of the flora of western Texas. Contributions of the U.S. National Herbarium.
- Deam, C. C.** 1940. Flora of Indiana. Burford Publishing Company, Indianapolis, Indiana.
- Deam, C. C.** 1953. Trees of Indiana. Bookwalter Company, Indianapolis, Indiana.
- Fox, S. F., and J. H. Soper.** 1954. The distribution of some trees and shrubs of the Carolinian Zone of southern Ontario. Part III. Transactions of the Royal Canadian Institute XXX(63): 99-130.
- Gibson, H. H.** 1913. American forest trees. Hardwood Record, Chicago, Illinois.
- Hanes, C. R.** 1947. Flora of Kalamazoo Co., Michigan. Schoolcraft, Michigan.
- Hough, R. B.** 1907. Handbook of the trees of the northern states and Canada east of the Rocky Mountains. Lowville, New York.
- Jensen, R. J.** 1977. A preliminary numerical analysis of the Red Oak complex in Michigan and Wisconsin. Taxon 26(4): 399-407.
- Little, E. L., Jr.** 1971. Atlas of United States trees. Volume 1. Conifers and important hardwoods. U.S.D.A. Forest Service Handbook No. 1146.
- Lotti, T.** 1965. Shumard Oak. Pp. 615-617 in *Silvics of forest trees of the United States*. Edited by H. A. Fowles. U.S.D.A. Forest Service Handbook No. 271.
- Macoun, J.** 1883-86. Catalogue of Canadian plants. Dawson Brothers, Montreal, Quebec.
- Maycock, P. F., O. R. Gregory, and A. A. Reznicek.** 1980. Hill's Oak (*Quercus ellipsoidalis*) in Canada. Canadian Field-Naturalist 94: 277-285.
- Meyers, G. A.** 1984. Some notes on Shumard Oak in the Hamilton-Niagara Region. Wood Duck 37(9): 141-148.
- Moore, D. M.** 1950. Trees of Arkansas. University of Arkansas, Fayetteville, Arkansas.
- Morsink, W. A. G., and P. D. Pratt.** 1984. Shumard Oak *Quercus shumardii*, in Essex County, Ontario. Canadian Field-Naturalist 98(4): 470-478.
- Oldham, M. J.** 1983. Environmentally significant areas of the Essex Region. Essex Region Conservation Authority, Essex, Ontario.
- Otis, C. H.** 1931. Michigan trees. Regents of the University of Michigan, Ann Arbor, Michigan.
- Palmer, E. J.** 1942. The Red Oak complex in the United States. The American Midland Naturalist 27: 732-740.
- Rehder, A.** 1940. Manual of cultivated trees and shrubs. Macmillan Publishing Company, New York.
- Richards, N. R., A. G. Caldwell, and F. F. Morwick.** 1949. Soil survey of Essex Co. Ontario Soil Survey Report 11. Ontario Agricultural College, Guelph, Ontario.
- Rowe, J. S.** 1972. Forest regions of Canada. Canadian Forestry Service Publication No. 1300, Ottawa.
- Sargent, C. S.** 1894. New or little-known plants. Garden and Forest 7: 514.
- Sargent, C. S.** 1895. *Quercus texana*. Silva of North America 8: 129-131.
- Sargent, C. S.** 1918. Notes on North American trees. I. *Quercus*. Botanical Gazette 65: 423-426.
- Sargent, C. S.** 1922. Manual of trees of North America. Houghton Mifflin, Boston, Massachusetts.
- Soper, J. H.** 1949. The vascular plants of southern Ontario. University of Toronto, Toronto, Ontario.
- Steyermark, J. A.** 1963. Flora of Missouri. Iowa State University Press, Ames, Iowa.
- Torrey, J.** 1859. Botany of the boundary in United States War Department Report on the United States and Mexican Boundary Survey (Washington). Volume 2(1).
- Torrey, J., and A. Gray.** 1857. Report on the botany of the expedition in United States War Department Pacific Railroad Reports (Washington). Volume 2.
- Vannorsdall, H. H.** 1958. Trees of Ohio. Wilmington, Ohio.
- Vines, R. A.** 1953. Native east Texas trees. Adco Press, Houston, Texas.
- Voss, E. G.** 1985. Michigan flora. Part two. Cranbrook Institute of Science, Bloomfield Hills, Michigan.

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Characteristics of Islands Selected by Nesting Canada Geese, *Branta canadensis*

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Characteristics of sites used by nesting Canada Geese were determined at Ogden Bay, Utah, in 1983. Muskrat lodges were generally avoided in favor of larger, man-made islands. In comparison with unused islands, nests chosen by geese were well-spaced (in response to territorial behavior) and tended to be located on islands 0.5 to 1.4 m in height, close to open water, and in shorter vegetation (for enhanced visibility). Comparisons with different races of Canada Geese suggest that nesting islands are chosen based on similar environmental cues. To increase use of earthen islands by nesting Canada Geese in similar areas, we recommend construction of relatively flat islands, at 100 m inter-island distances, 2 to 4.5 m in diameter, with a height of 1 m above water level.

Key Words: Canada Geese, *Branta canadensis*, nesting islands, nest site characteristics.

The use of man-made nest sites, either islands or structures, by Canada Geese, *Branta canadensis*, is well documented (Will and Crawford 1970; Johnson et al. 1978; Fielder 1979; Giroux et al. 1983). Specifications for construction of small artificial islands should ensure maximum benefit to geese in a cost-effective manner. Managers presently attempting to construct islands can use specifications determined from studies in which numerous physical and vegetative variables were measured at used and unused sites and from important variables detected through discriminant function analysis (Kaminski and Prince 1977; Giroux et al. 1983). While valuable as an explanatory function (Johnson 1981; Williams 1981), the approach that various authors have used has limitations. Data on used and unused sites are normally measured during laying or incubation periods, but not during the period when pairs are actively selecting nest sites. The impact of this time lag on the selection of habitat is unknown. In addition, whereas variables important in nest location are reported, the predictive equations generated from multivariate analyses are not, thus precluding testing the results of a study in other locations.

Our objectives were (1) to determine the environmental factors important to Canada Geese (*B. c. moffitti*) in Utah when birds are selecting island nest sites, (2) to evaluate these findings in relation to previous work in other areas of North America, and (3) to make recommendations for construction of artificial islands.

Study Area and Methods

The study was conducted in Unit 1 of Ogden Bay Waterfowl Management Area in northern Utah

(Kadlec 1982). The entire eastern portion of Unit 1 was drained in April 1981 (Smith and Kadlec 1983), and in midsummer approximately 225 small, artificial islands were constructed with a bulldozer in monotypic stands of Cattail (*Typha* spp.), Tule Bulrush (*Scirpus acutus*) and phragmites (*Phragmites australis*) by refuge personnel to provide habitat for upland nesting birds. The islands were not compacted, flattened or seeded. The unit was reflooded to a water depth of 0.2 m in fall 1981.

In January 1983 we selected for study two small, diked subunits and a portion of a third, with a total area of 53 ha. The area contained approximately 120 artificial islands and 50 Muskrat, *Ondatra zibethica*, lodges. Vegetative and structural features of every third island and Muskrat lodge (systematically sampled) were measured between 12 February and 5 March 1983. We recorded island type (artificial or lodge), island diameter (or the largest distance for islands not round), height, distance to open water, percent occurrence of vegetation, height of emergent aquatic vegetation around the island (after Kaminski and Prince 1977), and water depth 1 m from the island in each cardinal direction. Water level remained stable throughout the nesting period. After nesting was completed, distance to nearest island, nearest dike and nearest nest were measured with a rangefinder for all goose nests and a random sample of 13 unused islands. On 23 April and 4 May all artificial islands and lodges were examined for goose nests. Nest success was not determined.

All data were tested for normality (Nie et al. 1975) prior to univariate t-tests. Distance and percent data were transformed using log (x+1) and arcsine, respectively (Zar 1974).

Results

Thirteen artificial islands and two Muskrat lodges were used as nest sites by Canada Geese, resulting in a density of 0.28 nests/ha. Univariate t-tests revealed no differences ($P > 0.1$) between used and unused islands and lodges in the 6 physical and vegetative variables (Table 1). Geese nested only on islands between 1.5 and 4.0 m in diameter even though 20% of the available islands were less than 1.5 or greater than 4.0. Muskrat lodges in the area were generally too small in comparison with islands to serve as nesting platforms. Although there were no differences related to mean height, islands > 1.4 m high were rarely used (1/6) and no islands under 0.5 m ($N = 14$) were used. Nesting islands tended to be closer to open water (2.4 vs. 4.9 m) and in shorter vegetation (53.5 vs 63.6 cm) than unused islands.

On the basis of the above characteristics, many islands appeared suitable for nesting geese but were unused. As Johnson (1981) indicated, there are three reasons why a species can be absent from an area. We are sure that we located all nests; therefore, either the islands were unsuitable for nesting, or, more likely, they were suitable but were unused for other reasons, such as a goose population inadequate to use all sites or intraspecific competition. We included the transformed distance data to examine these influences on nest location because Giroux et al. (1983) reported that distance of islands from shore was important to nesting geese in the vicinity of Strathmore, Alberta.

Distance variables were measured for only 13 of the unused islands due to time constraints. Prior to including these data, we tested whether these adequately represented all the unused islands by comparing their six vegetative and physical characteristics to the 27 additional unused islands. There were no differences ($P > 0.1$) between the groups; therefore, we proceeded to compare the distance measurements between 13 nesting islands and 13 unused islands.

Analysis of the 26 islands revealed the influence of spacing between goose pairs (Table 2). Mean transformed distance to nearest nest was greater for nesting islands than for non-nest islands (2.14 vs 1.89, $t = 2.876$, 24 df, $P < 0.01$). Eighty-five percent (11/13) of nests were > 95 m apart; only 2 were < 95 m (both 62 m). Nests were well spaced, reflecting the territorial behavior of geese.

Discussion

Spacing behavior of the geese seemed to render many of the islands, which appeared acceptable on the basis of physical and vegetative characteristics, unsuitable as nest locations. If a greater number and density of geese were present nests would have perhaps been located more closely together. Naylor (1953), Geis (1956), Bednarik (1970), and Vermeer (1970) noted geese nesting in closer proximity than reported here. However, these birds were using closely spaced, artificial nest platforms or larger (0.2-25 ha) islands rather than the small islands (≤ 0.0028 ha) available in our study.

Our results agree with those reported for Giant Canada Geese (*B. c. maxima*) nesting on Muskrat lodges in Michigan (Kaminski and Prince 1977) and for geese using rock islands and straw bales in Alberta (Giroux et al. 1983). Both *B. c. maxima* and *B. c. mollitti* in three different habitats under different population densities selected nest sites based on similar characteristics.

Early workers (Brakhage 1966; Sherwood 1968) suggested that nest sites for geese be at least 45 m apart. Giroux et al. (1983) recommended 100 m as the inter-island distance. Our data also support a greater distance, and if the space between islands is open water with sparse vegetation, 125 m may be more appropriate. Islands can be constructed within stands of cattail or bulrush if one side provides access to open water.

TABLE 1. Environmental characteristics (mean \pm sd) of islands and lodges used and unused by Canada Geese as nest sites at Ogden Bay, 1983.

Variable	Islands		Lodges	
	Used (N = 13)	Unused (N = 40)	Used (N = 2)	Unused (N = 17)
Island diameter (m)	2.8 \pm 0.8	2.8 \pm 1.2	0.9 \pm 0.2	0.8 \pm 0.2
Island height (m)	0.9 \pm 0.3	0.9 \pm 0.3	0.5 \pm 0.0	0.4 \pm 0.1
Distance to open water (m)	2.4 \pm 2.7	4.9 \pm 6.9 ^a	14.0 \pm 0.0	9.1 \pm 5.4
Percent vegetation	54.4 \pm 26.0	43.6 \pm 26.4	54.0 \pm 9.9	51.5 \pm 23.9
Water depth (m)	1.3 \pm 3.0	1.7 \pm 2.2	7.0 \pm 4.2	3.7 \pm 4.5
Vegetation height (cm)	53.5 \pm 23.5	63.6 \pm 35.9	44.0 \pm 2.8	51.2 \pm 20.0

^aN = 13 only for distance.

TABLE 2. Spatial characteristics (mean \pm sd) of islands used and not used by Canada Geese as nest sites at Ogden Bay, 1983.

Variable	Used (N = 13)	Unused (N = 13)
Distance to nearest island (m)	35.4 \pm 22.5	28.6 \pm 20.2
Distance to nearest dike (m)	88.1 \pm 61.4	66.1 \pm 24.1
Distance to nearest nest (m) ^a	153.9 \pm 71.8	82.7 \pm 39.5

^aSignificant at $P < 0.01$ when transformed data were compared.

Sherwood (1968), Rienecker (1971) and Giroux et al. (1983) recommended that island nest sites be placed 15-60 m from mainland shore. Distance from shore was not important in our study because 77% of the nests were > 50 m from shore, as were 71% of unused islands. In addition, public access to Ogden Bay was restricted during the breeding season; this greatly reduced human disturbance. Depending on the extent of human and animal disturbance along the shore, we suggest islands be constructed at least 45 m from shore.

Earthen islands should be relatively flat and 2 to 4.5 m wide to provide a nest platform and to allow for erosion. Height of the islands at construction should be adjusted to provide a nest site 1 m above water level after reflooding. This will allow for settling and compaction of the soil to produce 0.5-0.8-m-tall islands over several years. Lack of vegetation on the islands did not appear to inhibit nesting by geese. The first year after construction at least 10 pairs nested on the new islands (S. Manus, personal communication).

The islands are maintenance-free during their usable life-span and when eroded away can be easily rebuilt. On another unit at Ogden Bay, islands were constructed in the same manner with similar dimensions. Depending on the exposure, ice conditions and Muskrat burrowing, they remained for five to seven years. If longer periods between drawdowns are necessary, seeding or placement of sod on new islands may promote vegetation establishment and retard erosion.

These recommendations apply only to island construction using an efficient, cost-effective method to increase use by nesting Canada Geese. Mallards (*Anas platyrhynchos*), Cinamon Teals (*A. cyanoptera*), Redheads (*Aythya americana*) and Ruddy Ducks (*Oxyura jamaicensis*) also used the islands for nesting and loafing. Where cost of construction is not a concern or where general goose, duck, and shorebird use is desired, islands of the dimensions described

above constructed at 50 m intervals would provide an adequate selection for all bird species.

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Literature Cited

- Bednarik, K.** 1970. Buckeye honkers. Pages 89-102 in Home grown honkers. *Edited by* H. H. Dill and F. B. Lee. United States Department of the Interior, Fish and Wildlife Service.
- Brakhage, G. K.** 1966. Tub nests for Canada geese. *Journal of Wildlife Management* 30: 851-853.
- Fielder, P. C.** 1979. Two techniques to improve nesting sites for Canada geese. *Wildlife Society Bulletin* 7: 62-63.
- Geis, M. B.** 1956. Productivity of Canada Geese in the Flathead Valley, Montana. *Journal of Wildlife Management* 20: 409-419.
- Giroux, J.-F., D. E. Jelinski, and R. W. Boychuk.** 1983. Use of rock islands and round straw bales by nesting Canada geese. *Wildlife Society Bulletin* 11: 172-178.
- Johnson, D. H.** 1981. The use and misuse of statistics in wildlife habitat studies. Pages 11-19 in The use of multivariate statistics in studies of wildlife habitat. *Edited by* D. E. Capen. United States Department of Agriculture, Forest Service General Technical Report RM-87.
- Johnson, R. E., Jr., R. O. Woodward, and L. M. Kirsch.** 1978. Waterfowl nesting on small man-made islands in prairie wetlands. *Wildlife Society Bulletin* 6: 240-243.
- Kadlec, J. A.** 1982. Mechanisms affecting salinity of Great Salt Lake marshes. *American Midland Naturalist* 107: 82-94.
- Kaminski, R. M., and H. H. Prince.** 1977. Nesting habitat of Canada geese in southeastern Michigan. *Wilson Bulletin* 89: 523-531.
- Naylor, A. E.** 1953. Productivity of the Canada Goose on Honey Lake Refuge, Lassen County, California. *California Fish and Game* 39: 83-94.
- Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent.** 1975. SPSS: Statistical package for the social sciences. McGraw-Hill Book Company, New York.
- Rienecker, W. C.** 1971. Canada goose nest platforms. *California Fish and Game* 57: 113-123.
- Sherwood, G. A.** 1968. Factors limiting production and expansion of local populations of Canada geese. Pages 73-85 in Canada goose management. *Edited by* R. C. Hine and C. Schoenfeld. Denbar Educational Resource Service, Madison, Wisconsin.
- Smith, L. M., and J. A. Kadlec.** 1983. Seed banks and their role during drawdown of a North American marsh. *Journal of Applied Ecology* 20: 673-684.
- Vermeer, K.** 1970. A study of Canada Geese, *Branta canadensis*, nesting on islands in southeastern Alberta. *Canadian Journal of Zoology* 48: 235-240.

- Will, G. C., and G. I. Crawford.** 1970. Elevated and floating nest structures for Canada geese. *Journal of Wildlife Management* 34: 583-586.
- Williams, B. K.** 1981. Discriminant analysis in wildlife research: Theory and applications. Pages 59-71 *in* The use of multivariate statistics in studies of wildlife habitat. *Edited by* D. E. Capen. United States Department of Agriculture, Forest Service General Technical Report RM-87.
- Zar, J. H.** 1974. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

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Characteristics of Logs Used by Western Red-backed Voles, *Clethrionomys californicus*, and Deer Mice, *Peromyscus maniculatus*

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Capture success at 48 structurally varied logs was compared for both the Western Red-backed Vole (*Clethrionomys californicus*) and the Deer Mouse (*Peromyscus maniculatus*). The number of vole captures was positively correlated with mean log diameter and the size of log overhang — that is, the semitriangular space between the edge of the log and the ground. Log overhang may provide cover and serve as a travel corridor for Western Red-backed Voles. The number of Deer Mouse captures was not significantly correlated with any of the measured log variables. The state of the log did not significantly influence capture success of either species.

Key Words: Red-backed Vole, *Clethrionomys californicus*, Deer Mouse, *Peromyscus maniculatus*, logs, microhabitat, Oregon.

A primary objective of many recent studies of microhabitat use by small mammals has been to identify and quantify important or essential habitat components that influence the distribution and abundance of small mammals (eg. Dueser and Shugart 1978; Yahner 1982). Once an essential habitat component is identified, further investigation of the relative influence of component variation on use of the habitat by small mammals is warranted. Dead and down woody material, including logs, is widely accepted as an important forest habitat component for many small mammal species (Maser et al. 1979). We are unaware, however, of any quantitative information published on the influence of specific log characteristics on the degree of use by small mammals.

Many authors have hypothesized that the Western Red-backed Vole, *Clethrionomys californicus*, is closely associated with logs (Tevis 1956; Gashwiler 1959; Ingles 1965; Maser et al. 1981), although Ure and Maser (1982) have captured Western Red-backed Voles in areas with very few logs. Goodwin and Hungerford (1979) found that capture success of Deer Mice, *Peromyscus maniculatus*, and the square feet of downed logs and stumps per acre were closely correlated. Deer Mice, however, occupy a wide variety of habitats (Baker 1968), many of which have few or no logs.

We analyzed capture success of Western Red-backed Voles and Deer Mice at structurally varied logs to ascertain the influence of specific log characteristics on microhabitat selection by these species.

Methods and Materials

Our study area is in the foothills of the southern Oregon Cascades, 23 km northeast of Ashland, T37S, R3E, sections 19 and 20, Willamette Meridian at ca. 900 m elevation. Slopes range from nearly flat to over 35°. Soda Creek, a small perennial creek, flows through the area. The study area is an old-growth forest in the mixed conifer zone (Franklin and Dyrness 1973). Douglas-fir (*Pseudotsuga menziesii*), Western Red Cedar (*Thuja plicata*), White Fir (*Abies concolor*), and Ponderosa Pine (*Pinus ponderosa*) are the dominant overstory species. The understory is composed of a variety of broad-leaved trees and shrubs. Shrubs and herbaceous cover are generally sparse but vary with aspect and distance to water.

We selected logs based on the following criteria: each log must be at least 3.9 m long (to accommodate traps), in contact with the ground over at least 80% of its length, and at least 1.0 m from the nearest log. For the study, we used the first 48 logs encountered that met these criteria. The selected logs ranged from 3.9 to 32.2 m in length.

We set 12 Sherman live traps (9 × 7.5 × 23.5 cm) at each log (Figure 1). A single row of three traps was placed as close as possible to the log (Row A). On the opposite side of the log, rows of three traps each were placed as close as possible to the log (Row B), 0.5 m from the log (Row C), and 1.0 m from the log (Row D). The three resulting columns of traps were located at the midpoint of the logs and 1.0 m from each end. All traps were parallel to the length of the log. Traps near the ends of the log were oriented with openings facing the nearest end, and at the midpoint of the log

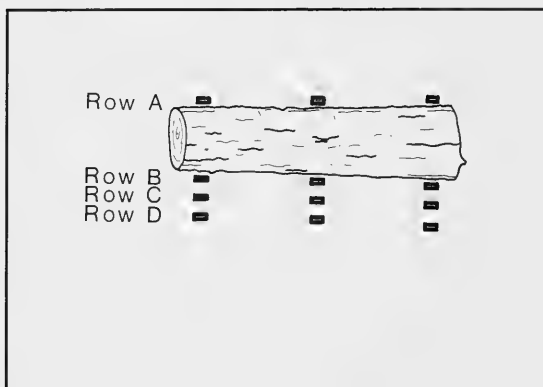


FIGURE 1. Location of Sherman live traps along logs.

the trap openings faced the end with the greater diameter.

Trapping was conducted from 4 August through 25 August 1982. Traps were baited with rolled oats. We set traps at eight logs for the first 4-day period and at 10 logs for each of the next four 4-day periods, resulting in a total of 2304 trap nights at 48 logs. We examined traps twice daily, once between 0800 h and 1100 h and once between 1600 h and 1800 h. Captured animals were identified, marked with a numbered metal ear tag (Salt Lake Stamp Co., Salt Lake City, Utah²), and released.

For each log, we determined length, mean diameter (the average of measures made at points corresponding to each of the three trap columns), mean overhang area (the average of measurements made at each of the Row A and Row B trap stations and midway between the end-trap and mid-trap stations; see Figure 2), percentage of moss (visually estimated), percentage of bark (visually estimated), and distance to the nearest log (the shortest distance from a Row A or Row B trap station to a log with a diameter > 25 cm and length > 4 m). Each log was classified as hard or soft based on the following criteria: hard logs were cylindrical and had hard wood over at least 75% of the surface; soft logs were in a more advanced state of decay, often were not cylindrical, and solid wood constituted $< 75\%$ of the log's surface.

We related the number of individuals captured per log to log length, mean log diameter, mean overhang area, percentage of bark, percentage of moss, and distance to the nearest log, using Spearman's rank correlation analysis. We also examined intercorrelations among the measured log characteristics. Because

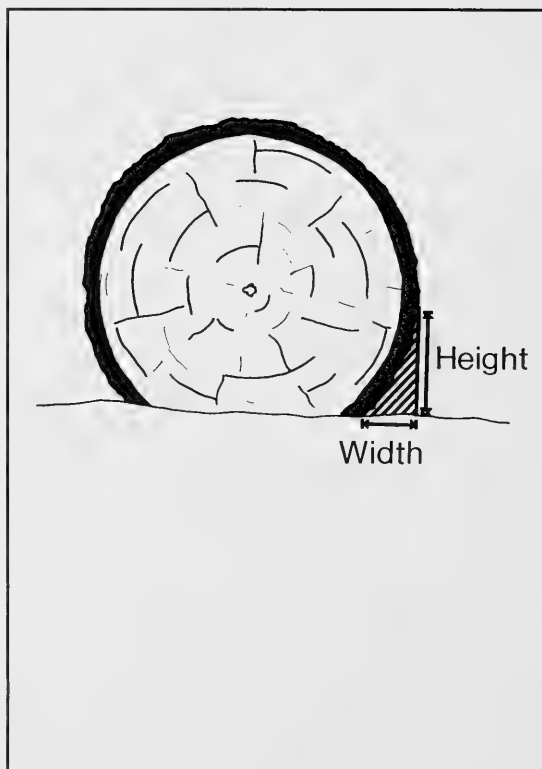


FIGURE 2. Cross-section of a log showing overhang height, width, and area (cross-hatched) on one side of a log. Overhang area was estimated as $\frac{1}{2} \times \text{overhang height} \times \text{overhang width}$.

we found significant intercorrelations between length, mean diameter, and mean overhang area, we examined partial correlations (Conover 1980) between these variables and the number of individual voles captured per log. Student's *t*-test was used to compare number of captures at hard and soft logs (Snedecor and Cochran 1980).

Results and Discussion

We captured 38 Deer Mice 116 times at 29 logs, and 19 Western Red-backed Voles 46 times at 20 logs. Discounting multiple captures of an individual at a given log, mice were captured 64 times and voles 31 times.

For voles, the only significant simple correlations between number of individuals captured per log and the examined log characteristics were positive associations with each of the three variables related to log mass: length ($\rho = 0.368$, $df = 46$, $P < 0.02$), mean diameter ($\rho = 0.450$, $df = 46$, $P < 0.01$), and mean overhang area ($\rho = 0.504$, $df = 46$, $P < 0.001$). These

²Use of trade names does not imply endorsement or approval by the USDA Forest Service.

three log variables were significantly intercorrelated ($\rho = 0.572$ to 0.781 , $df = 46$, $P < 0.001$). Partial correlation between number of voles and log length while mean diameter and mean overhang area are held constant was small ($\rho = 0.086$). Tests of significance for partial correlations depend on distributional assumptions (Conover 1980), which may not be met with these data. The small partial correlation coefficient, however, suggests that associations between capture of voles and length of logs merely reflect the correlation of log length with mean diameter and mean overhang area.

Partial correlation between number of voles and mean overhang area while diameter is held constant ($\rho = 0.273$) is higher than the partial correlation between number of voles and mean diameter while mean overhang area is held constant ($\rho = 0.106$), suggesting that overhang area may influence distribution more strongly than does mean log diameter. However, the relatively low magnitude of the partial correlation coefficients indicates that the effects of overhang area and log diameter can not be fully separated from one another. Thus, caution should be used in inferring causation.

The association between the number of individuals captured per log with mean diameter and mean overhang area suggests that logs with large diameters and large or consistent overhangs are used by Western Red-backed Voles more frequently than logs with small diameters or small, poorly developed overhangs.

Small mammals often use logs as travel and escape routes (Smith and Speller 1970; Barry and Francq 1980). Logs with large diameters and well-developed overhangs probably provide protective cover for small mammals (Maser et al. 1979). Thus, vulnerability to predation by birds and large mammals may be reduced when voles travel along the edge of logs with large overhang areas. Logs with large overhang areas might also be used as refuges or escape routes by voles foraging or travelling nearby.

The number of Deer Mice captured per log was not significantly correlated with any of the measured log variables. Largest simple correlation coefficients were obtained for associations between number of individuals with distance to the nearest log ($\rho = -0.257$) and with log length ($\rho = 0.276$), but these correlations were not statistically significant ($0.05 < P < 0.10$, $df = 46$).

No statistically significant differences between number of individuals captured at hard and soft logs were detected for either voles ($t = .45$, $df = 45$, $P > 0.5$) or mice ($t = 1.16$, $df = 46$, $P > 0.2$). These data imply that the state of log decay may not significantly influence habitat use by either

species. The absence of significant correlations between animal captures and percentage of cover by moss and percentage of cover by bark also suggest that state of log decay does not strongly influence use of microhabitat by these species.

Our findings do not negate the possibility of previously hypothesized associations between the Western Red-backed Vole and "rotting, punky logs" (Maser et al. 1981). Animals using soft logs may be using travel routes under or within the log, thereby decreasing their susceptibility to predation and capture. Using our trapping design, we may have failed to capture animals travelling in or under soft logs.

Additionally, small mammals may use soft and hard logs for different purposes. For example, soft logs may provide foraging and nesting sites and hard logs may be used as travel corridors and navigational aids. Differences in amount of utilization of these logs thus may be a poor indicator of the importance of these habitat components.

Our analyses are based on a number of assumptions. We assumed that probability of capture was constant among logs. We also assumed that differences in capture success reflected microhabitat selection based on measured characteristics of the logs. Finally, we assumed that the number of individuals captured at a log can be used as a reasonable index of microhabitat utilization by that species. We have no evidence to suggest that any of these assumptions have been violated.

Additional studies of forest-dwelling small mammals are needed to unravel the relation of wildlife to fallen logs. The utilization of the interior of logs, the specific uses of different types of logs, and the importance of spatial patterns of logs in determining habitat utilization patterns are areas of research that may be particularly interesting. Radio-telemetry may be useful to determine the frequency of use within soft logs and beneath hard logs, and to determine the patterns of movements between logs.

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Literature Cited

Baker, R. H. 1968. Habitats and distribution. Pp. 98-126 in *Biology of Peromyscus* (Rodentia). Edited by J.A. King. American Society of Mammalogists, Stillwater, Oklahoma.

Barry, R. E., Jr., and E. N. Francq. 1980. Orientation to landmarks within the preferred habitat by *Peromyscus leucopus*. *Journal of Mammalogy* 61: 292-300.

Conover, W. J. 1980. Practical nonparametric statistics. Second edition. John Wiley and Sons, New York. 493 pp.

Dueser, R. D., and H. H. Shugart, Jr. 1978. Microhabitats in a forest-floor small-mammal fauna. *Ecology* 59: 89-98.

Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA Forest Service General Technical Report PNW-8. 417 pp.

Gashwiler, J. S. 1959. Small mammal study in west-central Oregon. *Journal of Mammalogy* 40: 128-139.

Goodwin, J. G., Jr., and C. R. Hungerford. 1979. Rodent population densities and food habits in Arizona ponderosa pine forests. Rocky Mountain Forest and Range Experiment Station Research Paper RM-214. 12 pp.

Ingles, L. G. 1965. Mammals of the Pacific states. Stanford University Press, Stanford, California. 506 pp.

Maser, C., R. Anderson, K. Cromack, Jr., J. T. Williams, and R. E. Martin. 1979. Dead and down woody material. Chapter 6, pp. 78-95 in *Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington*. Edited by J.W. Thomas, USDA Agricultural Handbook 553. 512 pp.

Smith, D. A., and S. W. Speller. 1970. The distribution and behavior of *Peromyscus maniculatus gracilis* and *Peromyscus leucopus noveboracensis* (Rodentia: Cricetidae) in a southwestern Ontario woodlot. *Canadian Journal of Zoology* 48: 1187-1199.

Snedecor, G. W., and W. G. Cochran. 1980. Statistical methods. Iowa State University Press, Ames, Iowa. 507 pp.

Tevis, L. L., Jr. 1956. Responses of small mammal populations to logging of Douglas-fir. *Journal of Mammalogy* 37: 189-196.

Ure, D. C., and C. Maser. 1982. Mycophagy of red-backed voles in Oregon and Washington. *Canadian Journal of Zoology* 60: 3307-3315.

Yahner, R. H. 1982. Microhabitat use of small mammals in farmstead shelterbelts. *Journal of Mammalogy* 63: 440-445.

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Small Mammals in Glyphosate-treated Clearcuts in Northern Maine¹

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Effects of glyphosate [N-(phosphonomethyl) glycine] on small mammals in four- to five-year-old clearcuts were evaluated by snap- and pit-trapping one area one year after treatment, one area two months before and after treatment, and one untreated control. All areas were sampled simultaneously in four trapping periods from July to October, 1984. Seven species were captured, but Masked Shrews (*Sorex cinereus*), Deer Mice (*Peromyscus maniculatus*), Southern Red-backed Voles (*Clethrionomys gapperi*), and Pygmy Shrews (*Microsorex hoyi*) comprised 97% of 290 captures. Only Southern Red-backed Voles were affected by glyphosate application, being significantly more abundant on the control and less numerous on the one-year-old spray area. No short-term changes in captures occurred after the 1984 herbicide application.

Key Words: Glyphosate, herbicide, small mammals, silviculture, Maine.

The use of herbicides in forest management in Canada and the United States is expanding. In Maine, herbicides are used to release young spruce (*Picea* spp.) and Balsam Fir (*Abies balsamea*) from angiosperm competitors. The total area treated in Maine has increased steadily since 1979 and reached ca. 11.3×10^4 ha in 1984 (McCormack 1985).

Although some research has been done in the Pacific Northwest (Black and Hooven 1974; Sullivan and Sullivan 1982) and in West Virginia (Kirkland 1978), few data are available on effects of this type of habitat alteration on small mammals in the northeastern United States. Our study was undertaken to assess short-term changes in a small mammal community after silvicultural herbicide treatment of young clearcuts.

Study Area and Methods

Field work was conducted in Piscataquis County, Maine (46° 00' N, 69° 15' W) from July to October 1984. The land is managed primarily for spruce-fir pulpwood. Three treatment areas of 10 to 20 ha each were located in a 40-ha clearcut that was whole-tree harvested in 1979-80 and planted with Black Spruce (*Picea mariana*) and White Spruce (*P. glauca*) in 1980. Balsam Fir and Red Spruce (*P. rubens*) were present as advanced natural regeneration.

Glyphosate, as Roundup®, was applied by helicopter at a rate of 2.25 kg/ha on one treatment area ("83") on 9 August 1983 to suppress Red Raspberry (*Rubus idaeus*), Quaking Aspen (*Populus tremuloides*), Red Maple (*Acer rubrum*), Pin Cherry (*Prunus pensylvanica*), Gray Birch (*Betula populifolia*), Paper Birch (*B. papyrifera*), and other angiosperms that may potentially compete with conifer regeneration. A second treatment area ("84") was aerially sprayed with glyphosate at the same rate on 6 September 1984, and a third treatment area was an unsprayed control ("C").

Two parallel trapping transects 30 m apart were established from a randomly located starting point in the 83, 84, and C areas; paired transects were located at least 100 m from treatment boundaries. Each transect had 20 stations spaced every 15 m. At each station, two snap-traps were set and baited with peanut butter and rolled oats, and were placed within 1.0 m of the station marker. At alternate stations, a single pit-trap was set. Trapping was conducted on 18-21 July, 4-9 August, 20-23 September, and 13-16 October 1984 (i.e., 4200 trap nights).

Chi-square analyses (Scheffler 1969) were used to examine differences in total captures of the four most abundant small mammal species relative to treatment area.

Results

Herbicide treatment in 1983 was judged to be effective; only Red Raspberry showed some tolerance to glyphosate, while other angiosperms were controlled. Sprayed Red Raspberry produced some new foliage (ca. 10% cover) where it occurred in dense patches, but it was not as vigorous as on the unsprayed control. As is typical of aerial spray operations, two narrow (< 5 m wide) strips were missed during herbicide application; the strips included 5 of 40 trapping stations. These five stations were all

dominated by Red Raspberry. Field observation of leaf margin necrosis in September-October indicated that broad-leaved species would also be suppressed by glyphosate application on the 84 treatment. However, substantial changes in plant cover were not anticipated until leaf-out in 1985.

A total of 290 individual small mammals, representing seven species, was captured (Table 1). Four species accounted for 97% of the captures: Masked Shrew (*Sorex cinereus*), 48% of all captures; Deer Mouse, (*Peromyscus maniculatus*), 24%; Southern Red-backed Vole, (*Clethrionomys gapperi*), 16%; and Pygmy Shrew (*Microsorex hoi*), 8%. Pit-traps were used because they increase capture of shrews (Macleod and Lethiecq 1963; Williams and Braun 1983); in the present study, 58% of all shrews were caught in pit-traps.

Relative composition of the total capture through time revealed that species responded differently to habitat, season, and/or trapping (Table 1). Deer Mice were the most consistent proportion of the catch through the season, while shrews increased and Southern Red-backed Voles decreased on all treatment areas in fall. Combining all sampling periods, only Southern Red-backed Voles were affected by herbicide treatment on the different areas ($\chi^2 = 17.74$, $p < 0.05$); they were more numerous on

the C and less numerous on the 83 site. Number of captures on the 84 site before ($\chi^2 = 2.20$, $p > 0.05$) and after ($\chi^2 = 3.81$, $p > 0.05$) application were similar to those on the C site (Table 2).

Discussion

Effects of herbicides on populations of small mammals depend on the extent of habitat alteration and specific habitat requirements of the fauna (Tietjen et al. 1967; Johnson and Hansen 1969; Black and Hooven 1974; Borrecco et al. 1979; Spencer and Barrett 1980). Small mammals in British Columbia showed no effect of glyphosate application one year after treatment in a 20-year-old Douglas-fir (*Pseudotsuga menziesii*) plantation (Sullivan and Sullivan 1982). Kirkland (1978) found that community composition of small mammals in West Virginia did not change after treatment with 2,4,5-T to release conifers, but microtines decreased slightly. In addition, 18 of 44 individuals captured before treatment were recaptured 10 weeks after treatment on the same trapping grid. Results presented here also suggest that glyphosate did not cause a short-term change in the small mammal community (Table 2).

Being dominated by Masked Shrews, Deer Mice, and Southern Red-backed Voles, the small mammal community in this study was comparable to those

TABLE 1. Number of captures of small mammals (N = 290) by trapping period and treatment (83 = glyphosate-treated in August 1983; 84 = glyphosate-treated in September 1984; C = Control) in northern Maine, 1984.

Species	Sampling Period												Totals		
	18-21 July			4-9 August			20-23 September			13-16 October					
	83	84	C	83	84	C	83	84	C	83	84	C			
<i>Sorex cinereus</i> , Masked Shrew	1	5	2	6	5	10	18	17	25	18	21	13	43	48	50
<i>Peromyscus maniculatus</i> , Deer Mouse	8	2	2	8	7	4	4	5	11	5	5	9	25	19	26
<i>Clethrionomys gapperi</i> , Southern Red-backed Vole	1	7	7	3	4	12	1	2	5	0	1	2	5	14	26
<i>Microsorex hoyi</i> , Pygmy Shrew	1	0	0	0	0	0	2	2	3	10	2	5	13	4	8
<i>Blarina brevicauda</i> , Short-tailed Shrew	0	0	0	0	2	0	0	2	0	0	0	1	0	4	1
<i>Synaptomys cooperi</i> , Southern Bog Lemming	0	0	0	0	0	0	1	0	1	0	1	0	1	1	1
<i>Zapus hudsonius</i> , Meadow Jumping Mouse	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Totals	11	14	11	18	18	26	26	28	45	33	30	30	88	90	112
Sampling Effort (trap night) ¹	300	300	300	500	500	500	300	300	300	300	300	300	1400	1400	1400

¹Includes both snap- (2 per station) and pit-traps (1 every other station).

TABLE 2. Distribution of captures on the 84 treatment area before (July-August) and after (September-October) glyphosate application (before and after captures from control area in parentheses).

	<i>P. maniculatus</i>		<i>S. cinereus</i>		<i>C. gapperi</i>		<i>M. hoyi</i>	
Before	9	(6)	10	(12)	11	(19)	0	(0)
After	10	(20)	38	(38)	3	(7)	4	(8)

reported in other studies in similar habitats not treated with herbicide (Richens 1974; Kirkland 1977; Martell and Radvanyi 1977). Because Southern Red-backed Voles prefer moist forest habitats with ground debris (Gunderson 1959; Kirkland and Schmidt 1982), their negative response to glyphosate was expected. Declining numbers of Southern Red-backed Voles as the season progressed on the 83 area may be explained by defoliation of overhead cover and exposure to evaporative drying of the area during summer.

Masked Shrews are often abundant (Burt and Grossenheider 1976), and their increase in numbers in early fall in our study was consistent with observations from Ontario (deVos 1957). Pygmy Shrews, although not widely captured in other studies (Martell and Radvanyi 1977; Swan et al. 1984), also became more numerous as summer progressed: 28% and 68% of their total capture occurred in September and October, respectively. The population peak could be attributed to a high reproductive potential or to removal of Masked Shrews (Table 1) which are also insectivorous.

In cataloguing the incidence of more than one capture of a species at a station over the entire study, 49 of 62 multiple captures occurred at stations where slash was a ground-cover component. If slash cover is used as foraging areas or travel routes by small mammals to avoid predation, perhaps greater activity and exposure to traps at stations with high amounts of slash accounted for multiple captures. Also, animals may prefer to nest and give birth in slash areas. If this is the case, harvesting and silvicultural regimes that create and maintain a site with less slash may support fewer small mammals. Although this site was whole-tree harvested, trees of unmerchantable size or species contributed to slash cover.

One year after glyphosate application, conditions were unfavorable only for Southern Red-backed Voles, while numbers of other species were not affected. Species richness of the small mammal community as a whole was not affected, but as with other habitat alterations, such as clearcutting (e.g.

Kirkland 1977), relative abundance of at least one species did change. Further study is needed to ascertain the persistence of differences between sprayed and unsprayed sites, mindful that herbicide treatments are intended to promote a different, commercially desirable, plant cover than would develop if the site were not treated.

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Literature Cited

- Black, H. C., and E. F. Hooven. 1974. Response of small mammal communities to habitat changes in western Oregon. Pp. 177-186 in *Wildlife and forest management in the Pacific Northwest*. Oregon State University, Corvallis, Oregon, 230 pp.
- Borrecco, J. E., H. C. Black, and E. F. Hooven. 1979. Responses of small mammals to herbicide-induced habitat changes. *Northwest Science* 53: 97-106.
- Burt, W. H., and R. P. Grossenheider. 1976. A field guide to the mammals. Houghton Mifflin Co., Boston. 289 pp.
- deVos, A. 1957. Peak populations of masked shrew in northern Ontario. *Journal of Mammalogy* 38: 256-258.
- Gunderson, H. L. 1959. Red-backed vole habitat studies in central Minnesota. *Journal of Mammalogy* 40: 405-412.
- Johnson, D. R., and R. M. Hansen. 1969. Effects of range treatment with 2,4-D on rodent populations. *Journal of Wildlife Management* 33: 125-132.
- Kirkland, G. L. 1977. Responses of small mammals to the clearcutting of northern Appalachian forests. *Journal of Mammalogy* 58: 600-609.
- Kirkland, G. L. 1978. Population and community responses of small mammals to 2,4,5-T. U.S.D.A. Forest Service Research Note PNW-314. 6 pp.
- Kirkland, G. L., and D. F. Schmidt. 1982. Abundance, habitat, reproduction, and morphology of forest-dwelling small mammals of Nova Scotia and southwest New Brunswick. *Canadian Field-Naturalist* 96: 156-162.
- Macleod, C. F., and J. L. Lethiecq. 1963. A comparison of two trapping procedures for *Sorex cinereus*. *Journal of Mammalogy* 44: 277-278.
- Martell, A. M., and A. Radvanyi. 1977. Changes in small mammal populations after clearcutting of northern Ontario black spruce forests. *Canadian Field-Naturalist* 91: 41-46.
- McCormack, M. L., Jr. 1985. Vegetation problems and solutions — Northeast. *Proceedings of the Southern Weed Science Society* 38: 315-326.
- Richens, V. B. 1974. Numbers and habitat affinities of small mammals in northeastern Maine. *Canadian Field-Naturalist* 88: 191-196.
- Scheffer, W. C. 1969. *Statistics for the biological sciences*. Addison-Wesley Co., Reading, Massachusetts. 231 pp.
- Spencer, S. R., and G. W. Barrett. 1980. Meadow vole population response to vegetational changes resulting

- from 2,4-D application. *American Midland Naturalist* 103: 32-46.
- Sullivan, T. P., and D. S. Sullivan.** 1982. Responses of small mammal populations to a forest herbicide application in a 20-year-old conifer plantation. *Journal of Applied Ecology* 19: 95-106.
- Swan, D., B. Freedman, and T. Dilworth.** 1984. Effects of various hardwood forest management practices on small mammals in central Nova Scotia. *Canadian Field-Naturalist* 98: 362-364.
- Tietjen, H. P., C. H. Halvorson, P. L. Hegdal, and A. M. Johnson.** 1967. 2,4-D herbicide, vegetation, and pocket gopher relationships in Black Mesa, Colorado. *Ecology* 48: 634-643.
- Williams, D. F., and S. E. Braun.** 1983. Comparison of pitfall and conventional traps for sampling small mammal populations. *Journal of Wildlife Management* 47: 841-845.

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Nongame Bird Communities on Managed Grasslands in North Dakota*

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Grazed native prairie, unmanipulated native prairie, and planted alfalfa-wheatgrass habitats each supported prairie bird species unique to that habitat type. Comparisons of the three habitats, using community coefficients and overlap indices, showed that grazed and alfalfa-wheatgrass habitats supported the most dissimilar or unique bird communities. All three habitat types, or habitats with similar vegetation structure, must be incorporated in grassland management plans to support all members of the mixed-grass prairie bird community.

Key Words: Grassland bird communities, managed grasslands, community coefficients, North Dakota.

Since the 1960s, the United States Fish and Wildlife Service has purchased wetland-upland complexes to provide habitat for breeding waterfowl in the northern prairie states. From 1960 to 1977, 90 456 ha were purchased in North Dakota (Arnold 1983). Much research has focused on waterfowl use of these areas or of plant communities similar to that found on these management units (Duebber 1969; Duebber and Lokemoen 1976; Cowardin and Johnson 1979; Kaiser et al. 1979), but only a few workers have documented nongame bird use of these public grasslands (Blankespoor 1980; Duebber 1981; Johnson et al. 1982).

Each year native prairie on private lands in the northern Great Plains is ploughed for agricultural purposes. Of the 5 193 954 ha of privately owned pasture and range remaining in North Dakota in 1967, an estimated 40% of the pastureland and 10% of the rangeland had been converted into cropland by 1982 (R. O'Clair, United States Department of Agriculture, personal communication). With the increased loss of private rangelands and hayfields to row crop agriculture, publicly managed grasslands have become islands of habitat for the native birds of the mixed-grass prairie amid vast tracts of cropland. Managers of public grasslands need information on the habitat needs of nongame species to develop management strategies to help compensate for the loss of native habitats on private lands.

The objectives of our study were to determine the species composition and density of bird communities associated with grazed native prairie, unmanipulated (idle) native prairie, and alfalfa-wheatgrass (seeded

grass-legume cover, Duebber et al. 1981) habitats on managed grasslands in North Dakota and to determine which habitat type(s) was (were) most important in supporting prairie bird communities.

Study Areas and Methods

In 1981 and 1982, we worked on 12 grassland management areas located on the Missouri Coteau geological formation in Stutsman and McIntosh counties, North Dakota (Figure 1, 47° N, 99° W). We established four, 6-hectare study plots for each of three habitat types: grazed native prairie, unmanaged (idle) native prairie, and alfalfa-wheatgrass grasslands. Each plot was on a different management area.

Bird counts were conducted on gridded (25 m × 25 m spacing) plots using the spot-map method (Kendeigh 1944). We usually were able to make three or four counts per morning. Counts usually were started one-half hour before sunrise and generally were completed by 1030 hours. We completed nine counts in 1981 and 15 in 1982 on each plot from early May to late June.

In that same period, we randomly sampled the plot vegetation using the point-quadrat method (Brown 1954) to determine the percentage cover of grass, forb, litter, and shrub, the percentage of bare ground, and the vertical density of the vegetation (Wiens 1969). We directly measured litter and used a modified Robel pole (Robel et al. 1970) to measure the effective height of the vegetation (height of vegetation at which the Robel pole is visually obstructed). We sampled 48 points per plot.

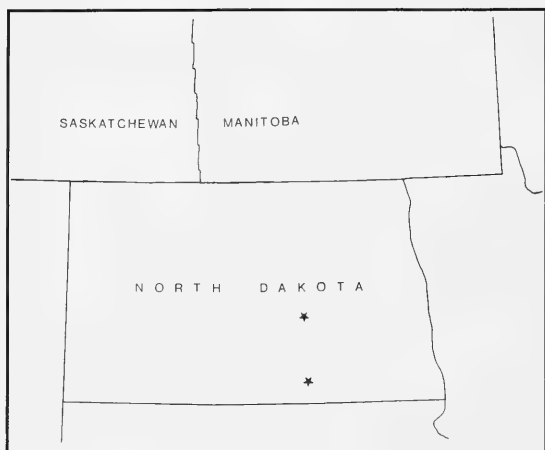


FIGURE 1. The stars indicate the general location of 12 grassland study sites in North Dakota.

Grazed study sites had not been grazed for three to four years before the study. The herbaceous cover was dominated by Green Needlegrass (*Stipa viridula*), Needle and Thread (*Stipa comata*), Blue Grama (*Bouteloua gracilis*), Little Bluestem (*Andropogon scoparius*), and Kentucky Bluegrass (*Poa pratensis*, Figure 2). The usual grazing regime used on the managed areas consisted of one month of crowd grazing (many cattle on an area) in the spring (generally in May), and then two to three years of rest.

For this study, the grazed study plots were grazed in the spring of both years. The grazing pressure applied to these areas ranged from 1.75 to 3.75 animal unit months per ha. In 1982, one grazed plot was managed very differently and we excluded this plot from further analyses. Hence, mean densities for bird species in the grazed habitats are derived from seven plots rather than eight.

Management areas on which idle prairie plots were located had not been grazed, burned, or mowed for 5 to 19 years before this study. Vegetation on these plots generally was matted, and all idle plots had a significant amount of shrub cover (Figure 3). Most of the shrub cover consisted of Wolfberry (*Symphoricarpos occidentalis*), but scattered stands of Silverberry (*Eleagnus commutata*) and Chokecherry (*Prunus virginiana*) were on a few plots. The herbaceous cover of idle habitats was dominated by the same plant species as on grazed plots.

The homogeneous stands of alfalfa-wheatgrass (or grass-legume cover) we studied had been established six to nine years preceding our investigation. The vegetation was a mixture of Alfalfa (*Medicago sativa*), Intermediate Wheatgrass (*Agropyron intermedium*), and Tall Wheatgrass (*Agropyron elongatum*, Figure 4.). This mixture was planted for duck nesting cover on previously tilled lands and was considered an interim cover type until native plant species could be economically planted.

Two-way analysis of variance was applied to bird densities to test for the effects of year, habitat, and



FIGURE 2. Grazed native prairie habitat.



FIGURE 3. Idle native prairie habitat.



FIGURE 4. Alfalfa-wheatgrass habitat.

year-habitat interactions. Differences in species densities among habitat types were compared with least-square mean tests. Differences among means of vegetation characteristics in the three habitat types were assessed by Duncan's multiple range tests.

We used breeding habitat and nest site descriptions from Stewart (1975) to determine what bird species observed in our study could be classified as prairie (grassland) nesting species. Any bird species that depended on or commonly used small trees and thickets of tall shrubs for nest sites (ex. Common Yellowthroat, *Geothlypis trichas*) were not considered to be members of the mixed-grass prairie bird community. Although one could argue that tree and tall-shrub nesting birds historically were found in the mixed-grass prairie and should be considered members of that community, we want to focus our attention on the bird species that rely upon typical (Stewart 1975) grassland habitat of the mixed-grass prairie for nesting.

Similarities among bird communities of the three habitat types were compared by calculating community coefficients (Samson and Knopf 1982) and Morisita-Horn overlap indices (Horn 1966) using mean species densities within a habitat type. Community coefficients represent overlap in the number of species between habitats, whereas Morisita-Horn indices combine overlap in the number of species and density between habitats. Smallest values for community coefficients and

overlap indices imply that the two habitats compared are most dissimilar. The most unique habitat shares the two smallest coefficients or indices.

Results

There was no year effect or year-habitat interaction in overall mean bird densities for the three habitat types. Therefore, the mean species densities reported in Tables 1, 2 and 3 are for the combined years.

Grazed and alfalfa-wheatgrass plots had 16 and 15 species of birds, respectively, and had mean bird densities of 48 territorial males/40 ha and 102 territorial males/40 ha, respectively (Tables 1, 2 and 3). Idle plots had a greater number of species (23) and more birds (mean density = 151 territorial males/40 ha) than grazed or alfalfa-wheatgrass plots (Tables 1, 2 and 3).

Grazed and idle habitats had eight native prairie bird species in common (Tables 1 and 2). Idle and alfalfa-wheatgrass habitats shared seven native prairie bird species (Tables 1 and 2), whereas grazed and alfalfa-wheatgrass habitats had fewer bird species (six) in common. More importantly, grazed, idle, and alfalfa-wheatgrass habitats respectively supported two, two, and three prairie nesting species unique to that habitat type (Table 3).

Vegetation structure differed among the three habitat types. Idle plots had more ($P < 0.05$) shrub cover than did grazed or alfalfa-wheatgrass plots (Table 4). Grazed plots had less ($P < 0.05$) forb cover and slightly more ($P < 0.05$) bare ground than did idle or alfalfa-wheatgrass plots. Grazed plots had shorter vegetation than alfalfa-wheatgrass plots, but the effective height of vegetation did not differ between idle and grazed plots, and between idle and alfalfa-

wheatgrass plots. The vegetation on idle and alfalfa-wheatgrass plots was more dense (greater mean number of vegetation contacts) than grazed plots. Grazed plots also had a thinner litter layer than idle or alfalfa-wheatgrass plots.

Alfalfa-wheatgrass habitats were the most dissimilar, based on comparisons of species richness (community coefficients, Table 5). This was true regardless of whether we included all species observed in the study or only bird species native to the mixed-grass prairies (Tables 1, 2 and 3). However, when both species richness and density were considered (Morisita-Horn index) grazed habitats were the most dissimilar.

Discussion

Instead of maximizing the number of species within a management unit, public land managers are now encouraged to maximize the number of species between habitats (Samson and Knopf 1982), i.e. provide large management units of varied habitat in mosaic pattern. With this philosophy in mind, we tried to determine which habitat types contributed the most to conserving the grassland nesting species of the mixed-grass prairie bird community. When we compared community coefficients, alfalfa-wheatgrass habitats appeared to be the most dissimilar type. When we used the Morisita-Horn similarity indices, which take into account species density as well as species richness, grazed areas were the most dissimilar habitat. Alfalfa-wheatgrass and grazed habitats occupy the extremes of the spectrum of vegetative structure available to the mixed-grass prairie bird community before European settlement (prior to 1870 in North Dakota).

TABLE 1. Bird species and mean densities (number of territorial males/40 ha) present in all habitat types.¹

Species	Mean Density		
	Grazed	Idle	Alfalfa-Wheatgrass
Upland Sandpiper, <i>Bartramia longicauda</i>	1.7 + 0.4 ³ A	1.3 + 0.3 A	0.2 + 0.2 B
Eastern Kingbird, <i>Tyrannus tyrannus</i>	4.2 + 2.0 AB	8.3 + 3.2 A	0.2 + 0.2 B
Common Yellowthroat, <i>Geothlypis trichas</i>	1.0 + 1.0 A	5.0 + 3.0 A	4.2 + 4.2 A
Clay-colored Sparrow, <i>Spizella pallida</i> ²	0.3 + 0.3 A	76.9 + 9.4 B	10.1 + 4.6 A
Savannah Sparrow, <i>Passerculus sandwichensis</i> ²	5.7 + 2.1 A	2.7 + 1.3 A	12.5 + 2.3 B
Grasshopper Sparrow, <i>Ammodramus savannarum</i> ²	10.0 + 3.2 A	9.6 + 4.0 A	4.3 + 2.9 A
Red-winged Blackbird, <i>Agelaius phoeniceus</i>	2.8 + 1.4 AB	4.0 + 1.2 A	0.8 + 0.8 B
Western Meadowlark, <i>Sturnella neglecta</i> ²	7.3 + 0.7 A	6.4 + 1.3 A	3.0 + 1.1 B
American Goldfinch, <i>Carduelis tristis</i>	0.5 + 0.5 A	8.7 + 3.3 B	1.0 + 0.8 A

¹Mean densities with the same letter are not significantly different.

²Species native to mixed-grass prairie (see text).

³Standard error of the density estimates.

TABLE 2. Mean densities (number of territorial males/40 ha) of bird species found in only two habitat types.¹

Species	Mean Densities		
	Grazed	Idle	Alfalfa-Wheatgrass
Killdeer, <i>Charadrius vociferus</i> ²	1.7 + 0.7 ³ A	0.2 + 0.2 B	0.0 B
Willet, <i>Catoptrophorus semipalmatus</i> ²	1.0 + 0.3 A	0.2 + 0.2 B	0.0 B
Marbled Godwit, <i>Limosa fedoa</i> ²	0.7 + 0.3 A	0.2 + 0.2 B	0.0 B
Sedge Wren, <i>Cistothorus platensis</i> ²	0.0 A	0.8 + 0.8 A	26.9 + 12.4 B
Baird's Sparrow, <i>Ammodramus bairdi</i> ²	3.8 + 1.8 A	0.0 B	2.1 + 0.9 AB
Song Sparrow, <i>Melospiza melodia</i>	0.3 + 0.3 A	2.7 + 1.3 A	0.0 A
Bobolink, <i>Dolichonyx oryzivorus</i> ²	0.0 A	1.5 + 1.5 A	31.2 + 7.0 B

¹Mean densities with the same letter are not significantly different.²Species native to mixed-grass prairie (see text).³Standard error of the density estimates.

Species such as the Dickcissel, Le Conte's Sparrow, and Sharp-tailed Sparrow were found only on alfalfa-wheatgrass plots, whereas Bobolinks, Sedge Wrens, and Savannah Sparrows were observed at significantly greater densities in alfalfa-wheatgrass. Likewise, Horned Larks and Chestnut-collared Longspurs were found only on grazed plots, and species such as Marbled Godwit, Killdeer, and Willet were observed in significantly greater densities in grazed habitats. Each species mentioned above has seemingly adapted to an extreme of the prairie vegetative structure continuum of short, sparse to tall, rank vegetation (Ryan 1986). These extremes are not found on unmanaged grassland habitats.

The only prairie species observed only in idle habitats were Common Snipe and Wilson's Phalarope. These species are closely associated with wetlands (Stewart 1975), and their presence in this

habitat was probably due to the presence of ponds on some idle plots. Other species unique to the idle habitat but not grassland nesters in the mixed-grass prairie are forest-edge, shrub-nesting species (Graber and Graber 1963; Stauffer 1978) that were attracted to the greater amount of Chokecherry and Silverberry present on some idle areas.

Surprisingly, we did not see Sprague's Pipit (*Anthus spragueii*), Lark Bunting (*Calamospiza melanocorys*), or Vesper Sparrow (*Poocetes gramineus*) on any plots. These three species are perhaps the only small bird species associated with the mixed-grass prairie (Stewart 1975) that were not represented in the communities we described. Suitable habitat for Vesper Sparrows, Sprague's Pipits, and Lark Buntings is seemingly available on the managed areas or could be available with small changes in habitat manipulation schemes.

TABLE 3. Mean densities (number of territorial males/40 ha) of bird species found in only one habitat type.¹

Species	Mean Densities		
	Grazed	Idle	Alfalfa-Wheatgrass
Common Snipe, <i>Gallinago gallinago</i> ²	0.0	1.5 + 1.2 ³	0.0
Wilson's Phalarope, <i>Phalaropus tricolor</i> ²	0.0	0.8 + 0.8	0.0
Mourning Dove, <i>Zenaidura macroura</i>	0.0	5.6 + 3.7	0.0
Willow Flycatcher, <i>Empidonax traillii</i>	0.0	7.9 + 5.5	0.0
Least Flycatcher, <i>Empidonax minimus</i>	0.0	0.3 + 0.3	0.0
Horned Lark, <i>Eremophila alpestris</i> ²	2.2 + 1.1 A	0.0 B	0.0 B
Gray Catbird, <i>Dumetella carolinensis</i>	0.0	2.3 + 1.6	0.0
Brown Thrasher, <i>Toxostoma rufum</i>	0.0	0.4 + 0.4	0.0
Yellow Warbler, <i>Dendroica petechia</i>	0.0	4.6 + 3.1	0.0
Dickcissel, <i>Spiza americana</i>	0.0	0.0	2.3 + 2.3
Le Conte's Sparrow, <i>Ammodramus leconteii</i> ²	0.0	0.0	1.5 + 1.5
Sharp-tailed Sparrow, <i>Ammodramus caudatus</i> ²	0.0	0.0	2.5 + 2.5
Chestnut-collared Longspur, <i>Calcarius ornatus</i> ²	5.5 + 3.3	0.0	0.0

¹Mean densities with the same letter are not significantly different.²Species native to mixed-grass prairie (see text).³Standard error of the density estimates.

TABLE 4. Vegetative structure characteristics of the three habitat types on management areas.¹

Vegetation structure	Habitat Type		
	Grazed	Idle	Alfalfa-Wheatgrass
Percent grass cover	49.0 A	63.2 AB	77.2 B
Percent forb cover	16.9 A	27.3 B	34.9 B
Percent litter cover	97.9 A	99.7 A	99.4 A
Percent shrub cover	0.8 A	18.2 B	0.1 A
Percent bare ground	1.2 A	0.1 B	0.2 B
Effective height (dm)	0.6 A	1.6 AB	2.6 B
Litter depth (cm)	1.8 A	3.0 B	3.6 B
Vertical Density ²	4.2 A	7.6 B	7.9 B

¹Means with the same letter are not significantly different.
²Mean number of vegetation contacts in 10-cm intervals between 0 and 70 cm.

TABLE 5. Comparisons of bird community similarities in species richness (community coefficients) and species richness and density (Morisita-Horn indices) among idle, grazed, and alfalfa-wheatgrass habitats.

Comparisons	Community Coefficients		Morisita-Horn Indices	
	All Birds	Prairie Birds	All Birds	Prairie Birds
Grazed – Idle	0.67	0.70	0.17	0.12
Grazed – Alfalfa-Wheatgrass	0.65	0.55	0.21	0.21
Idle – Alfalfa-Wheatgrass	0.58	0.61	0.27	0.24

Vesper Sparrows have been observed on grazed (Karasiuk et al. 1977; Kantrud 1981), ungrazed (Maher 1973; Karasiuk et al. 1977), and agricultural habitats (Owens and Myres 1973; Rodenhouse and Best 1983). The pipit and bunting are associated with shorter grass, moderately grazed mixed-grass prairie communities (Kantrud 1981) and short-grass prairies (Owens and Myres 1973). Sprague’s Pipit and Lark Bunting may benefit from management schemes that incorporate long-term grazing in the mixed-grass prairie region.

We recommend that public land managers in the northern prairie region view individual management tracts as part of a mosaic of habitats in the mixed-grass prairie. Small tracts may be managed as a single habitat type. Large tracts may be managed with a mix of habitats along the continuum of short, sparse to tall, dense vegetation. Thus, managers can provide a variety of habitat types within a mosaic pattern. We also recommend that managers pay special heed to the habitat requirements of bird species that occupy the extremes of the vegetative continuum. This may require managers to incorporate more ungulate grazing and taller, dense vegetation (like native tall grasses) within management schemes to ensure that habitat is available for these species.

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Literature Cited

Arnold, P. M. 1983. A wetland manager’s view of waterfowl production in North Dakota. *Naturalist* 34: 20–23.
Blankespoor, G. W. 1980. Prairie restoration: effects on nongame birds. *Journal of Wildlife Management* 44: 667–672.
Brown, D. 1954. Methods of surveying and measuring vegetation. Commonwealth Agricultural Bureaux, Bulletin 42. Farnham Royal, Bucks., England. 233 pp.
Cowardin, L. M., and D. H. Johnson. 1979. Mathematics and mallard management. *Journal of Wildlife Management* 43: 18–35.
Duebbert, H. F. 1969. High nest density and hatching success of ducks on South Dakota CAP land.

- Transactions of the North American Wildlife and Natural Resources Conference 34: 218-229.
- Duebbert, H. F.** 1981. Breeding birds on waterfowl production areas in northeastern North Dakota. *Prairie Naturalist* 13: 19-22.
- Duebbert, H. F., and J. T. Lokemoen.** 1976. Duck nesting in fields of undisturbed grass-legume cover. *Journal of Wildlife Management* 40: 39-49.
- Duebbert, H. F., E. T. Jacobson, K. F. Higgins, and E. B. Podoll.** 1981. Establishment of seeded grasslands for wildlife habitat in the prairie pothole region. U.S. Fish and Wildlife Service Special Scientific Report — Wildlife. 234. 21 pages.
- Graber, R. R., and J. W. Graber.** 1963. A comparative study of bird populations in Illinois, 1906-1909 and 1956-1958. *Illinois Natural History Survey Bulletin* 28: 383-528.
- Horn, H. S.** 1966. Measurement of overlap in comparative ecological studies. *American Naturalist* 100: 419-424.
- Johnson, D. H., C. A. Faanes, and J. M. Andrew.** 1982. Kentucky blue grass prairie and mixed prairie I-VIII. *American Birds* 36: 79-80.
- Kaiser, P. H., S. S. Berlinger, and L. H. Frederickson.** 1979. Response of blue-winged teal to range management on waterfowl production areas in southeastern South Dakota. *Journal of Range Management* 34: 295-298.
- Kantrud, H. A.** 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. *Canadian Field-Naturalist* 95: 404-417.
- Karasiuk, D., H. Vriend, J. G. Stelfox, and J. R. McGillis.** 1977. Study results from Suffield, 1976. Pages E33-E44 in *Effects of livestock grazing in mixed grass range and wildlife within PFRA pastures, Suffield Military Reserve. Compiled by J. G. Stelfox.* Canadian Wildlife Service, Edmonton, Alberta.
- Kendeigh, S. C.** 1944. Measurement of bird populations. *Ecological Monographs* 14: 67-106.
- Maher, W. J.** 1973. Birds: I. Population dynamics. Canadian Committee for the International Biological Programme. Matador Project, Technical Report 34. University of Saskatchewan, Saskatoon, Saskatchewan. 56 pp.
- Owens, R. A., and M. T. Myres.** 1973. Effects of agriculture upon native passerine birds of an Alberta fescue grassland. *Canadian Journal of Zoology* 51: 697-713.
- Robel, R. J., J. N. Briggs, A. D. Dayton, and L. C. Hulbert.** 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. *Journal of Range Management* 23: 295-297.
- Rodenhouse, N. L., and L. B. Best.** 1983. Breeding ecology of vesper sparrows in corn and soybean fields. *American Midland Naturalist* 110: 265-275.
- Ryan, M. R.** 1986. Nongame management in grassland and agricultural ecosystems. Pages 117-136 in *Management of nongame wildlife in the Midwest: a developing art. Edited by J. B. Hale, L. B. Best, and R. L. Clawson.* Symposium proceedings, 47th Midwest Fish and Wildlife Conference. Sponsored by the North Central Section of The Wildlife Society.
- Samson, F. B., and F. L. Knopf.** 1982. In search of a diversity ethic for wildlife management. *Transactions of the North American Wildlife and Natural Resources Conference* 47: 421-431.
- Stauffer, D. F.** 1978. Habitat selection by birds of riparian communities: evaluating the effects of habitat alteration. M.Sc. thesis, Iowa State University, Ames, Iowa. 86 pp.
- Stewart, R. E.** 1975. Breeding birds of North Dakota. Tri-College Center for Environmental Studies, Fargo, North Dakota. 295 pp.
- Wiens, J. A.** 1969. An approach to the study of ecological relationships among grassland birds. *Ornithological Monographs* 8: 1-93.

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Seasonal Movements and Home Range Utilization Patterns of the Black Bear, *Ursus americanus*, in Western Manitoba

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Seasonal movements and home range characteristics of Black Bears (*Ursus americanus*) were studied in an agriculture-forest ecotone in western Manitoba from May 1979 to November 1980 using radio telemetry. Subadult males utilized a significantly larger home range (506.4 km²) than subadult (35.2 km²) or adult females (29.1 km²). Similarly, males used larger seasonal ranges than females and showed much greater variability in utilization patterns. Adult and subadult females showed up to 100 percent overlap of their home range. The extensive overlap of seasonal ranges indicated overlap was both spatial and temporal. Subadult males traveled farther between locations than subadult or adult females during all seasons. Animals moved freely between forested areas and the agricultural lands, but while in the agricultural zone, restricted their movements primarily to wooded areas, ravines and shelter belts. Females did not undertake extensive movements away from their summer activity centers whereas subadult male activity was characterized by irregular and wide ranging movements, often into the adjacent provincial forest. The observed home range utilization and movement patterns differ from some studies conducted in forested areas and may be related to the high mortality and population turnover rate of bears in the current study.

Key Words: Black Bear, *Ursus americanus*, home range, movement patterns, agriculture.

The Black Bear (*Ursus americanus*) has adapted well to changing land use practices and retains an extensive range in North America (Cowan 1972). The development of agriculture and forestry has greatly decreased the amount of bear habitat in many areas and Black Bear populations are now often confined to remnant tracts of forested land, national parks or forest reserves. Although numerous studies have examined various aspects of Black Bear ecology in forested habitat (Jonkel and Cowan 1971; Rogers 1977; Young and Ruff 1982), little information is available on movement patterns and habitat utilization in agricultural land or forest-agriculture ecotones. While there is general agreement on the solitary nature of North American bears (Ewer 1973), Black Bears exhibit a range of spacing behavior under different conditions. Several studies have indicated that female Black Bears are territorial (Rogers 1977; Young and Ruff 1982) while others have concluded overlapping home ranges were more common (Amstrup and Beecham 1976; Garshelis and Pelton 1981). Crook (1970) and Crook et al. (1976) have outlined the numerous internal and external factors which are important in shaping the social system and spacing patterns of a species. In addition to differences arising from environmental factors, spacing behavior may be influenced by excessive mortality which can keep a population in a "state of flux" (Hornocker 1976; Hornocker and Hash 1981)

and prevent the establishment of normal spacing behavior.

The wide ranging activities and omnivorous food habits of Black Bears often result in direct conflict with agricultural practices and many bears are often destroyed in areas where damage occurs regularly (Gunson 1977). Where losses are excessive, the generally low reproductive rate of bears (Jonkel and Cowan 1971) may be supplemented by immigration from adjacent areas. High mortality of resident animals and recruitment through immigration may influence the age structure, sex ratio and residence time of animals in the area. If spacing behavior is affected by these variables, differences would be expected between populations with varying degrees of harvest pressure.

Along the eastern edge of the Duck Mountain Provincial Forest (DMPF) in western Manitoba, varied agricultural practices have created a mosaic of forested and developed land. Depredation problems on apiaries, grainfields and livestock result in numerous animals being destroyed annually in addition to the removal of bears by hunters and trappers. This situation provided an opportunity to study home range utilization and spacing behavior of a Black Bear population apparently kept in a state of flux by a high mortality rate.

Study Area

The main study area is situated in west-central Manitoba (51°37'N, 100°35'W) and consists of a 260 km² quadrat bisected by the eastern boundary of the DMPF (Figure 1). Trapping was restricted to the central portion of the main study area but animals were monitored up to 60 km away.

Wide seasonal fluctuations in temperature occur with mean January and July temperatures of -19 and +19°C respectively. Average annual precipitation at lower elevations is approximately 43 cm. Mean annual snowfall is 120 cm and although variable, the period 1 November to 15 April normally has snow accumulations exceeding 10 cm (Environment Canada, Dauphin, Manitoba). Physiography of the DMPF consists of ice scoured or morainic uplands

with numerous rock outcrops and a rolling to hilly topography (Barto and Vogel 1978).

The eastern boundary of the DMPF divides the main study area into the broad categories of forest and agricultural land based on predominant land use practices. With the exception of occasional livestock grazing on the periphery, no agricultural activities are carried out within the provincial forest and natural vegetation predominates. Vegetation in the DMPF is primarily of the mixed wood type with Trembling Aspen (*Populus tremuloides*), Balsam Poplar (*P. balsamifera*), Paper Birch (*Betula papyrifera*), White Spruce (*Picea glauca*), and Balsam Fir (*Abies balsamea*) forming the dominant overstory associations. Jack Pine (*Pinus banksiana*) and Black Spruce (*Picea mariana*) or Tamarack (*Larix laricina*) are commonly found in sandy uplands and poorly drained areas respectively. Common shrub species include Beaked Hazel (*Corylus cornuta*), Red-osier Dogwood (*Cornus stolonifera*), willow (*Salix* spp.), Speckled Alder (*Alnus rugosa*), Highbush Cranberry (*Viburnum opulus*), Saskatoon (*Amelanchier alnifolia*) and several cherry species (*Prunus* spp.). Characteristic understory plants include Sarsaparilla (*Aralia nudicaulis*), Dewberry (*Rubus pubescens*), Wild Strawberry (*Fragaria virginiana*) and numerous grasses.

Where undisturbed, natural vegetation in the agricultural lands is very similar to that in the adjacent DMPF. Of particular importance to bears are numerous mast and berry producing shrubs along ravines, watercourses and the edge of fields. The amount of cleared farmland varies from 90 percent to less than 5 percent on farms used as woodlots. The proportion of forested land and the size of woodlots decreases with increasing distance from the DMPF. On the average, pasture and cropland involve 40 and 30 percent of the total farm area respectively. Predominant agricultural practices include the production of livestock and raising of forage and cereal crops (Barto and Vogel 1978).

Methods and Materials

Bears were captured with Aldrich leg snares (Aldrich Animal Trap Co., Clallam Bay, Washington) at trapsites placed along ravines or in forested areas showing signs of bear activity. Techniques similar to those outlined in Johnson and Pelton (1980) were used with the exception that larger quantities of bait were provided. Trapping continued throughout much of 1979 but was restricted to the spring in 1980 to eliminate the potential influence of baitsites on movement and foraging patterns.

All bears were immobilized using a combination of ketamine hydrochloride [Ketaset, Rogar STB] and

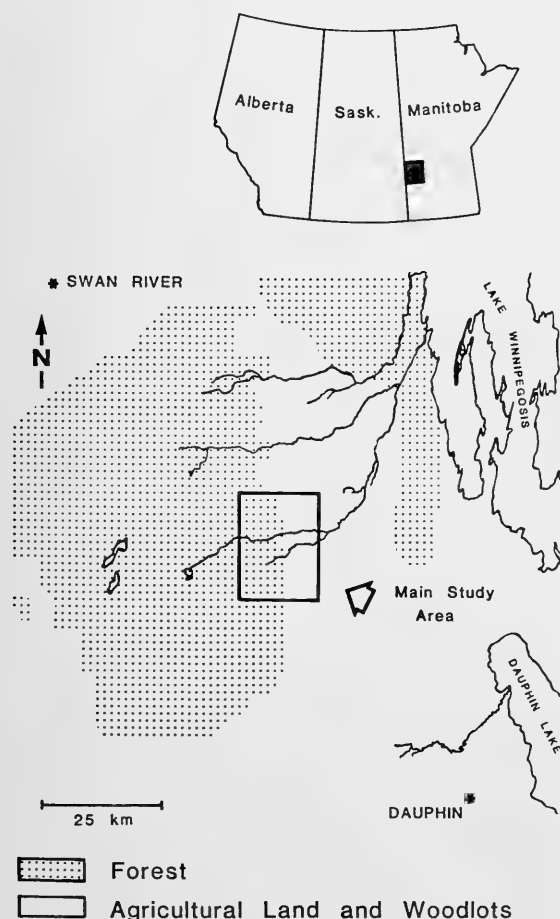


FIGURE 1. Location of the study area in western Manitoba.

xylazine hydrochloride [Rompun, Bayvet] (Addison and Kolenosky 1979) in a 2:1 ratio administered intramuscularly by a jab-pole syringe. Upper and lower first premolars were extracted from all bears captured (except cubs) and their age estimated using counts of cementum annuli (Willey 1974). Animals were classified as cubs (< 1 year), yearlings (1-2 years), subadults (2-4 years) and adults (> 4 years).

Twenty-five bears were equipped with transmitters which had a motion sensing device that indicated when the animal was active. Standard telemetry triangulation and monitoring techniques were employed throughout the study (Brander and Cochran 1969). Ground tracking was conducted from a vehicle equipped with a collapsible 14 element directional antenna or by ground searchers using a small hand-held antenna. Precision of the monitoring system (determined from 20 trials on known transmitter locations) was generally within three degrees of the true azimuth. When required, animals were located from the air using a Cessna 172 aircraft equipped with two, four-element directional antennas.

From May to late September 1980 an attempt was made to obtain a minimum of four to ten sequential daily locations to represent movements. Bears were located between 0600 and 2300 hr after confirming nocturnal inactivity through several 24 h monitoring periods. In 1980, all animals were located when searched for even when they had moved outside the main study area. Bears which moved to and remained at locations greater than 20 km from the intensive study area were monitored less frequently.

Annual data were separated into three periods based on phenology for seasonal comparisons. Only bears with more than 13 locations were used in these analyses. Spring (April to 15 June) began with emergence from the winter den and continued to the end of the period during which green vegetation and carrion made up the food supply. The presence of ripe mast and berry crops was used to delineate summer (16 June to 31 August). The fall period (1 September to 15 November) was marked by a substantial decrease of both green vegetation and mast crops. Data from 1979 were not separated into seasons due to insufficient locations to evaluate the seasonal range accurately. Repeated observations at the den site were omitted once inactivity was established.

Home range area was estimated using the Jennrich and Turner index [95% utilization ellipse] (Jennrich and Turner 1969). This estimate does not assume a circular range and is statistically unbiased with respect to sample size. Although 95% utilization ellipses are known to be consistently larger than the minimum convex polygon (Mohr 1947) estimate (Garshelis and

Pelton 1981), sample size inconsistencies and differences in monitoring intensity between animals make the Jennrich and Turner index (JTI) a more appropriate estimate for the present study (W. Klenner, unpublished data; Mares et al. 1980; Voigt and Tinline 1980). Home range and seasonal range areas were compared using a one-way analysis of variance and Duncan's multiple range test on log transformed data and were based on a minimum of 13 locations.

Home range stability between years and seasonal range stability was evaluated using the distance between activity centers and the Student's *t*-test. A shift was considered significant if the distance was greater than the radius of the minor summer home range axis. Home range overlap of adult and subadult females was evaluated using the minimum convex polygon (MCP) since this estimate uses discrete boundaries around the outermost locations and provides a more conservative estimate of home range overlap than the JTI. To avoid including animals which lived in separate areas, I assessed overlap for animals which showed greater than ten percent overlap of their home ranges. Home range overlap between females and subadult males was not evaluated quantitatively since the extensive home range of a male often included the ranges of all females being monitored in the main study area.

The distance between successive locations was used to evaluate movement patterns. A weighted, unbalanced split plot analysis of variance design on log transformed data [overall MSE used to test for between season differences, animal within cohort MSE used to test for cohort differences] (Steel and Torrie 1980) and Duncan's multiple range test were used to test for differences in cohort and seasonal movements. Unless otherwise indicated, all comparisons used an error level of $\alpha = 0.05$ to test for significant differences.

Results

Home Range Comparisons

Fifteen telemetry equipped bears were located 345 times in 1979. In 1980, 17 animals were monitored more intensively and located 1361 times. Background information on individual animals monitored is presented in Table 1. Seasonal and annual home range areas for all cohorts are listed in Table 2 which also includes the MCP area for comparison. All animals which had portions of their home range in forest and agricultural land ($n = 12$) moved freely between the two types of habitat and utilized these areas without noticeable avoidance or attraction to either region. However, bears tended to restrict their activities to areas with cover when using agricultural land. Signs

TABLE 1. Weight, age and reproductive status of Black Bears monitored by radio-telemetry.

†Bear Number	Date of first capture	Number of telemetry locations		Date-weight (kg)	*Age at first capture	°Reproductive status		Comments
		1979	1980			1979	1980	
F791	7/6/1979	30		7/6/79 - 46	2	SA		
F792	15/6/1979	22	79	15/6/79 - 43 5/6/80 - 50	3	SA	SA	2 cubs, March 1981
F793	16/6/1979	40	84	16/6/79 - 40 18/8/79 - 58	2	SA	SA	2 cubs, March 1981
F795	25/7/1979		51	25/7/79 - 75 23/6/80 - 81	8	A	A	3 cubs, June 1980
F796	25/7/1979	30	75	25/7/79 - 68 1/9/80 - 100	4	SA	A	3 cubs, June 1980
F797	1/8/1979	9		1/8/79 - 64	3	SA		
F798	1/8/1979	29	101	1/8/79 - 34 12/10/79 - 48	1	Y	SA	
F799	1/8/1979	28		1/8/79 - 36	1	Y		
F7910	18/8/1979	26		18/8/79 - 75	5	A		2 cubs in 1979
F7911	18/9/1979	12		18/9/79 - 93	4	A		2 cubs in 1979
F801	9/5/1980		77	9/5/80 - 71	6		A	3 cubs, March 1981
F802	16/5/1980		84	16/5/80 - 56	3		SA	2 cubs, March 1981
F807	2/6/1980		80	2/6/80 - 70	5		A	
F809	9/6/1980		78	9/6/80 - 50	2		SA	
F8010	11/6/1980		79	11/6/80 - 73	7		A	3 cubs, March 1981
F8011	12/6/1980		88	11/6/80 - 61	3		SA	
F8012	20/6/1980		84	20/6/80 - 75	9		A	3 cubs, March 1981
M791	15/6/1979	6		15/6/79 - 66	2	SA		
M792	17/6/1979	22		17/6/79 - 95	5	A		
M793	27/7/1979	25	90	27/7/79 - 72 13/5/80 - 88	2	SA	SA	
M794	1/8/1980	27		1/8/79 - 47 15/10/79 - 66	1	Y		
M795	18/8/1979	21	88	18/8/79 - 64 10/6/80 - 98	2	SA	SA	
M796	18/8/1979	18	92	18/8/79 - 72 25/5/80 - 72	2	SA	SA	
M804	10/6/1980		55	10/6/80 - 139	5		A	
M807	19/6/1980		76	19/6/80 - 57	2		SA	

†F = female, M = male.

*based on cementum annuli counts, standardized to month of birth.

°Y = yearling, SA = subadult, A = adult.

of bear activity and numerous scats found along the edge of fields and shelterbelts indicates that these areas are used as feeding sites. In contrast to the relatively small home ranges of female bears (Figure 2), subadult and adult males ranged over very large areas (Figure 3). In 1980, subadult male home ranges (506.4 km²) were larger than subadult (35.2 km²) or adult female (29.1 km²) home ranges ($F = 11.03$; $df = 2,12$; $p = 0.006$). Subadult males utilized significantly larger fall ranges than females ($F = 8.84$; $df = 2,8$; $p = 0.009$). The lack of significant differences in spring and summer is the result of a small sample size and high subadult male variability which itself is an important characteristic of this cohort. Subadult

females showed a tendency toward utilizing larger home range and seasonal range areas than adult females but the difference was not great enough to be significant. In comparison to both subadult males and females, adult females showed the least variability between individuals (Table 2). All cohorts utilized larger spring than summer or fall ranges but these differences were not significant. Only one adult male which ranged over a very large area (95% utilization ellipse of 2921.9 km²) was monitored in 1980. Comparisons to other cohorts were not made since it is not known if this animal was representative.

Although the data from individual bears monitored in both 1979 and 1980 are difficult to compare directly

TABLE 2. Home range and seasonal range of Black Bears in western Manitoba based on the Jennrich and Turner (1969) index. Minimum convex polygon values are indicated in parentheses.

Cohort	Year	Season	n	Mean (km ²)†	SE	Range	
Female							
Adult	1979	Annual	2	14.0 ()°	0.9	13.1- 14.9	
Subadult			4	60.2 (28.1)	13.5	37.9- 99.3	
Yearling			2	26.2 (14.1)	10.2	16.0- 36.4	
Male							
Adult			1	148.9 ()	55.0	133.9- 324.0	
Subadult			3	224.6 ()			
Yearling			1	20.2 (8.0)			
Female							
Adult	1980	Annual	5	29.1 (23.9)	5.2	19.7- 47.8	
		Summer	6	26.4 (21.0)	4.7	14.3- 46.0	
		Fall	3	15.4 ()	4.6	10.4- 24.7	
		Subadult	Annual	6	35.2 (25.7)	12.5	9.0- 92.6
		Spring	2	48.2 ()	37.9	10.3- 86.1	
		Summer	6	30.9 (20.1)	12.0	9.0- 86.6	
		Fall	6	23.0 ()	9.6	5.2- 64.3	
Male							
Adult			Annual	1	2921.9 (989.0)	171.8	254.5- 991.9
	Summer		1	3036.9 (989.0)			
Subadult		Annual	4	506.4 (417.6)	202.0	587.2-1210.8	
		Spring	3	807.4 ()	136.2	29.1- 597.6	
		Summer	4	189.3 (145.0)	145.6	130.1- 448.4	
		Fall	2	213.8 ()			

†JTI calculations involve animals with a minimum of 13 locations.

°Minimum convex polygon estimate provided only for animals with a minimum of 30 locations.

(logistic constraints reduced monitoring efficiency in 1979 and several animals were tracked for only part of the year in 1979), the following trends are suggested. Subadult male ranges were smaller in 1979 (224.6 vs 506.4 km²) while subadult females utilized larger areas (60.2 vs 35.2 km²). Adult females used smaller areas (14.0 vs 29.1 km²).

Within a season, individual animals often showed wide variation in the area used over a shorter time period. This was determined by evaluating the area used during a "moving" 15 location period (early locations deleted as new ones added). These results show wide variability about the seasonal mean; indicating animals do not utilize the home range in a uniform manner (both spatially and temporally) but instead concentrate their activity in local areas (decrease in area used) for varying periods before moving to a different location. Only two subadult females whose seasonal ranges were less than ten km² showed little fluctuation about the seasonal mean.

The distribution of locations within the home range of individual animals indicated substantial variation in the pattern of habitat use. Of the 17 animals monitored in 1980, the east-west coordinates of only one animal and north-south coordinates of seven animals did not differ significantly from a normal distribution (Kolmogorov-Smirnov test for normal-

ity; Steel and Torrie 1980). Certain animals showed a tendency towards a random utilization distribution while others exhibited a contagious pattern with most locations in several intensively used areas.

Home Range Stability and Overlap

All animals which survived from 1979 to 1980 (n = 7) had stable home ranges with the observed shifts small in relation to the minor home range axis. Seasonal ranges were stable for all cohorts in 1980 with the following exceptions. Two subadult females and two subadult males showed substantial shifts from spring to summer. Two females and one male made significant changes in the seasonal range utilized from spring to fall while one female and three subadult males undertook range shifts from summer to fall. A comparison of seasonal range shifts indicates no difference in the mean distance moved between adult and subadult females. During the spring to summer period subadult males showed a greater shift in the activity center of their seasonal range (9.5 km) than either subadult (1.6 km) or adult females (1.6 km) [t = 5.75, df = 6, p = 0.002; t = 5.13, df = 2, p = 0.030 respectively]. This difference is the result of subadult males using a den site located far away from the summer range and a period of activity in this area in spring before returning to the summer range. Female

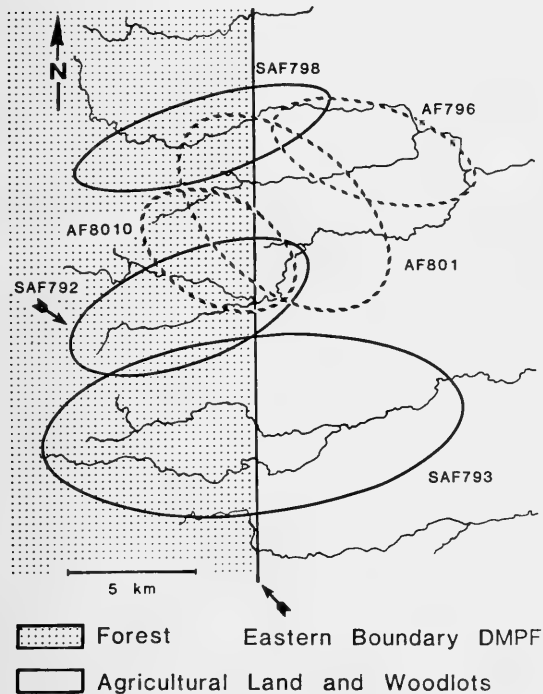


FIGURE 2. Home ranges of representative subadult (SAF) and adult (AF) female Black Bears in western Manitoba during 1980. The areas indicated represent 95 percent utilization ellipses.

ranges were more stable and showed less change than subadult males from spring to fall ($t = 3.66$, $df = 7$, $p = 0.008$) as well as between the summer and fall range ($t = 3.36$, $df = 12$, $p = 0.006$).

Home range overlap between male bears being monitored was extensive, ranging from 30 to 100 percent of the home range area. Since additional unmarked subadult and adult males were known to make at least periodic use of the main study area, overall home range overlap between males was probably higher than I documented. Home range overlap between males and females was also extensive. The home range of male M795 overlapped all females being monitored in the study area (compare Figures 2 and 3, noting differences in scale). Even male M793, whose restricted movements in 1980 resulted in a smaller than average home range, overlapped six adult and subadult females.

Of the 12 adult and subadult females monitored in 1980, there were 22 combinations which showed greater than ten percent overlap of their MCP home range (Table 3). Regression analysis indicated a

strong relationship between the proportion of the home range and the proportion of locations in the zone of overlap ($r = 0.90$, $p = 0.001$). Annually, overlap between subadult-subadult ($n = 8$, $\bar{x} = 40.0\%$), adult-adult ($n = 8$, $\bar{x} = 39.7\%$) and subadult-adult females ($n = 28$, $\bar{x} = 31.1\%$) did not differ significantly. All groups showed a significant decrease in overlap during fall when movements were restricted to localized areas. Extensive home range overlap by three adult females in one area was also recorded (Figure 4). It is important to note that these are conservative estimates of home range overlap since additional, unmarked animals may have been present in the study area. Data collected in 1979 were of insufficient resolution for a detailed analysis of overlap, however, the same general trend of extensive overlap between females was observed.

Movement Patterns

A summary of differences in movement patterns between seasons ($F = 8.08$; $df = 2, 1214$; $p = 0.003$) and cohorts ($F = 7.74$; $df = 2, 13$; $p = 0.006$) is presented in Table 4. In general, subadult males showed greater movements than females during all seasons. Although subadult females consistently traveled farther

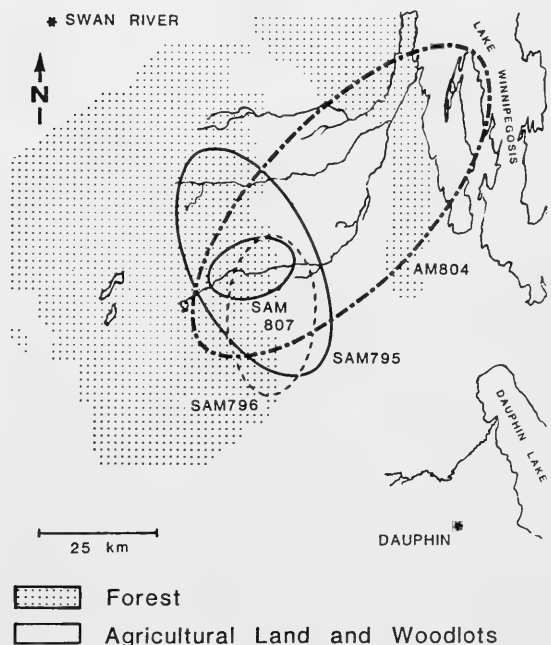


FIGURE 3. Home ranges of representative subadult (SAM) and adult (AM) male Black Bears in western Manitoba during 1980. The areas indicated represent 95 percent utilization ellipses.

TABLE 3. Overlap of female Black Bear minimum convex polygon home ranges during 1980.

Animal Number		Number of locations		Home range area (km ²)		Overlap (km ²)		% of home range in overlap		Number of locations in overlap		% of total locations in overlap	
A	B	A	B	A	B	A	B	A	B	A	B	A	B
*SAF792	SAF809	80	78	26.1	31.8	8.0	31	25	37	25	46	32	
SAF792	SAF802	80	84	26.1	12.0	1.6	6	13	15	9	19	11	
SAF798	SAF8011	101	88	19.8	7.4	2.8	14	37	20	44	20	50	
SAF802	SAF809	83	77	12.0	31.8	10.7	89	34	79	26	95	34	
SAF792	SAF801	80	79	26.1	32.1	2.8	11	9	19	4	24	5	
SAF792	AF8010	80	79	26.1	16.1	6.6	26	41	34	30	43	38	
SAF792	AF8012	80	84	26.1	29.0	2.6	10		14	0	18	0	
SAF793	AF807	96	82	56.5	20.7	17.6	31	85	51	78	53	95	
SAF798	AF796	101	75	19.8	21.7	3.3	17	15	4	4	4	5	
SAF798	AF801	101	79	19.8	32.1	5.2	26	16	8	16	8	20	
SAF798	AF8012	101	84	19.8	29.0	10.4	53	36	60	33	59	39	
SAF802	AF801	83	79	12.0	35.1	10.0	83	31	80	27	96	34	
SAF809	AF801	78	79	31.8	35.1	17.4	55	54	48	44	62	56	
SAF802	AF8010	83	79	12.0	16.1	9.4	78	58	73	62	88	79	
SAF802	AF8012	83	84	12.0	29.0	9.8	81	34	68	19	82	23	
SAF809	AF8010	78	79	31.8	16.1	15.7	49	97	31	77	40	98	
SAF809	AF8012	78	84	31.8	29.0	12.7	40	44	13	21	17	25	
SAF8011	AF8012	88	84	7.4	29.0	1.9	26	7	30	11	34	13	
AF796	AF801	75	79	21.7	32.1	4.7	22	15	3	5	4	6	
AF801	AF8010	79	79	32.1	16.1	8.9	28	55	22	63	28	80	
AF801	AF8012	79	84	32.1	29.0	13.0	41	45	34	49	43	58	
AF8010	AF8012	79	84	16.1	29.0	11.7	72	40	56	17	71	20	

*SAF indicates subadult female, AF indicates adult female.

between locations than adult females, these differences were not significant. A second trend evident in Table 4 is an overall decrease in the distance traveled between locations by females from spring to fall. Subadult males show a decrease in summer but increased movements again in fall. Average subadult male movements in spring were exaggerated by the return from a remote den site, whereas in fall, decreased overall movements are obscured by travel to a remote area for denning by some animals. Unlike 1979 when all subadult males denned in peripheral areas, only two of four subadult males moved far into the DMPF to den in 1980.

I recorded only one instance of an excursion by a female away from her summer range; on 8 September 1979, a subadult female traveled a minimum of seven km into the DMPF. After several days, she returned to her summer range where a den was constructed in October. During both years, subadult males exhibited irregular and wide-ranging movements, often westward into the DMPF. Travel by subadult males to peripheral regions in 1979 undoubtedly went undetected since the animals could not be monitored adequately by vehicle. The return of subadult male

M793 to his summer range from the 1979 den site (a distance of over 40 km) within two days illustrates the mobility of bears. The return movement, through a densely forested area with numerous lakes which would hamper direct travel, suggests the actual distance traveled was probably much greater. Similar movements by M796 (return from den site to the spring and summer range) and M795 during frequent mid-summer wanderings further exemplifies the mobility of subadult males.

Discussion

Home Range Utilization

The concept of home range in mammals was first formally addressed by Burt (1943) who defined home range as the area "traversed by the individual in its normal activities of food gathering, mating and caring for young". Occasional excursions outside this area should not be considered part of the home range. I concur with this definition and find it readily applicable to female Black Bear movement patterns which were restricted to a relatively small, intensively utilized area. The home range areas recorded for female Black Bears in both 1979 and 1980 are within

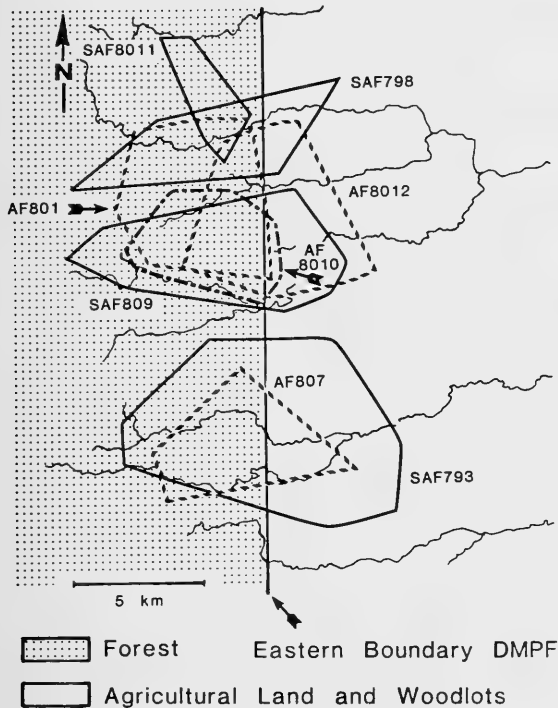


FIGURE 4. Home range (minimum convex polygon) overlap of subadult (SAF) and adult female (AF) Black Bears during 1980.

the range of values reported from other studies. While Rogers (1977) observed female territories averaging 9.6 km² in northeastern Minnesota, Amstrup and Beecham (1976) reported much larger home ranges of 48.9 km² in Idaho. Some caution is advised when comparing the results of the present study to other reports due to different sample sizes, methods of data collection or analysis.

In addition to occupying much larger home ranges, the subadult males monitored in this study also showed greater variability in the size of home ranges between individuals. Unlike female home ranges, the large areas utilized by subadult males are difficult to evaluate, falling somewhere between the "living areas" described by Messier and Barrette (1982) for Coyotes (*Canis latrans*) and the definition of home range outlined by Burt (1943). The deletion of five percent of the outermost locations is often used to eliminate excursions from the home range estimate, however, this technique is not valid unless all locations represent equal monitoring effort. Decreased monitoring of subadult males during their frequent

wanderings into inaccessible regions created a bias in the data. If each location is weighted (to represent the time spent in the area), the subadult males monitored in this study spent greater than 25 percent of their time away from the main study area. The use of the same areas from 1979 to 1980 and the repeated use of distant areas by subadult males led me to include these as part of the home range.

In Idaho, Reynolds and Beecham (1980) observed average adult and subadult male Black Bear home ranges of 60 and 46 km² respectively. Young and Ruff (1982) indicated average subadult male ranges of 119 km² but reported some monitoring constraints which they felt may have led to an underestimate of the actual area. The differences in reported male ranges and those observed in this study are substantial and probably reflect differences in habitat, social status and population density.

Subadult animals in the process of choosing, establishing or becoming acquainted with a home range would be expected to wander over larger areas than established residents. I believe the large and variable size of subadult male home ranges observed in the present study reflect differences in the social status of individuals. The extensive wanderings may be related to becoming familiar with resources and other occupants or alternatively may be the result of interactions with mature males and subsequent avoidance behavior (Kemp 1976). The removal of three adult male bears from the main study area in 1979 and four in 1980 would be expected to decrease the number of interactions between adult and subadult males, making it less likely that aggressive interactions with mature males caused the observed patterns. In addition to the removal of adult males, a minimum of two and nine subadults and yearlings were removed in 1979 and 1980 respectively.

Reynolds and Beecham (1980) also indicated high variability in the home range size of subadult males and indicated social status was probably a key factor involved. I believe male bears in my study area were subject to a high mortality rate as a result of hunting, trapping and the destruction of animals during depredation control activities. Of the six male bears marked in 1979, three had been killed by May 1980. Since I was not able to obtain an accurate estimate of the density of Black Bears in my study area, the mortality rate is not known. However, the results of a concurrent carcass collection program (unpublished data) and anecdotal reports from local residents led me to believe that the mortality rate of marked animals I observed in the main study area may be representative of the periphery of the DMPF. Limited access to much of the interior of the DMPF has created a situation where the mortality (associated

TABLE 4. Mean distance (in km) between sequential locations (± 1 SE) of Black Bears monitored during 1980. The number of distance measurements during each season is indicated in parentheses.

Cohort	n	Spring	Summer	Fall
Subadult male	4	5.7 (40) $\pm 1.36^{1,a}$	3.1 (217) $\pm 0.23^{2,a}$	3.4 (73) $\pm 0.61^{2,a}$
Subadult female	6	2.5 (47) $\pm 0.29^{1,a}$	1.9 (330) $\pm 0.08^{2,b}$	1.2 (112) $\pm 0.13^{3,b}$
Adult female	6	1.8 (30) $\pm 0.18^{1,a}$	1.8 (322) $\pm 0.07^{1,b}$	1.1 (69) $\pm 0.15^{2,b}$

Note: Identical numeric superscripts indicate means across seasons which are not significantly different (Duncan's multiple range test; $\alpha = 0.05$); identical alphabetic superscripts indicate means which are not significantly different across groups.

with human activities) of bears on the periphery is much greater than in the interior. As suggested by Kemp (1976), these conditions may promote immigration by bears from surrounding areas.

When viewed over a shorter time period, seasonal ranges exhibit a dynamic element which indicates non-random use of the area used. Direct observations and data on movement patterns confirm the periodic fluctuations in area utilized. Animals which were located in a restricted area for up to several weeks often switched to extensive movements until localized activity was again resumed. When searched, the areas of intense activity often had an abundance of ripe fruit or berries and showed signs of bear foraging activities. The observed variability in short term home range utilization may be the result of foraging patterns which are influenced by habitat heterogeneity and the fluctuating availability of food sources. As localized food abundances are depleted or diminish, periods of extensive foraging follow and continue until another patch is located.

Home Range Stability and Overlap

The low proportion of females which undertook a seasonal range shift suggests that the mosaic of natural habitat and agricultural lands within their ranges was sufficiently diverse to support seasonal foraging during the two years of study. These results contrast with the work of Garshelis and Pelton (1981) who indicated major shifts in the seasonal range of females in response to food abundances outside the home range. Changes in subadult male ranges from spring to summer and summer to fall were probably related to the use of den sites located away from the summer range.

The high degree of overlap of males, females and between males and females in the present study is comparable to the widespread overlap reported by Garshelis and Pelton (1981). Since very large areas are involved, Black Bears may not be able to maintain exclusive use of their home range because of the high cost involved in repelling intruders (Brown 1964). Alternatively, Amstrup and Beecham (1976)

concluded that the extensive home range overlap of bears observed in Idaho resulted from the sporadic availability of patchy and abundant food sources. In an environment where temporary, scattered and unpredictable food sources predominate, tolerance and home range overlap would be expected (Brown and Orians 1970).

In contrast, both Rogers (1977) and to a lesser extent, Young and Ruff (1982) observed little overlap of female ranges due to the aggressive defense of individual territories. Although it has been documented that female bears may tolerate their offspring on parts of their territory (Rogers 1977), this would not explain the extensive overlap between several adult females. In addition to the habitat differences between the present and the above two studies, social instability may have contributed to increased home range overlap in my study. Between June 1979 and May 1980, five (three subadult, two adult) of ten females being monitored were removed by hunters and trappers or during depredation control activities. Males were also subject to high mortality as indicated above. Bears in less accessible forested areas to the west of the main study area are exposed to a relatively low human induced mortality and may form a reservoir of animals which replenish bears removed in more accessible areas. A high turnover rate would increase the opportunity for transient animals to settle in the area and may preclude the establishment of defended territories.

Movement Patterns

Black Bear movement patterns observed during this study reflect the high mobility of subadult and adult males and sedentary nature of females. The movement of subadult males into agricultural areas from forested regions was documented previously by Young and Ruff (1982) and would be expected in my study area. Continued removal of animals from the periphery of the forested lands would presumably create a dispersal sink open for colonization by immigrants. There was also a tendency towards decreased use of a remote den site by subadult males in

the second year of the study. Whereas all three subadult males monitored in 1979 moved greater than 20 km from their summer activity center to construct dens in the DMPF (\bar{x} = 33.3, SE = 6.9), the distance moved by these same animals in 1980 was less (\bar{x} = 9.0, SE = 5.5). Although the natal site of subadult males monitored in the present study remains unknown, I feel that the use of a remote den site, frequent excursions into the DMPF and decreased use of remote areas for denning during the second year of the study as animals matured suggests that these animals originated from within the DMPF.

In conclusion, female Black Bear home range utilization patterns in a forest-agriculture ecotone are characterized by intensive use of relatively small home ranges which appear to provide the required resources and obviate the need for excursions or periodic foraging away from the home range. In contrast, subadult males utilized much larger areas and periodically travelled far into the DMPF. The observed differences in female spacing behavior between this and other studies may be a function of high human-induced mortality which results in a high turnover rate of animals in the area and precludes the establishment of exclusive territories.

In terms of Black Bear management and control of depredations by bears in agriculture-forest ecotones, only a fraction of the problem will probably be eliminated by removing or destroying animals at the site of damage. The removal of resident animals will likely be offset by the recruitment of animals through reproduction by remaining residents and the immigration of bears from adjacent areas. A more effective, long-term solution would involve a program of preventative measures aimed at protecting apiaries and livestock along with the selective removal of certain problem animals.

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Literature Cited

- Addison, E. M., and G. B. Kolenosky. 1979. Use of ketamine hydrochloride and xylazine hydrochloride to immobilize black bears (*Ursus americanus*). *Journal of Wildlife Diseases* 15: 253-258.
- Amstrup, S. C., and J. Beecham. 1976. Activity patterns of radio-collared black bears in Idaho. *Journal of Wildlife Management* 40: 340-348.
- Barto, W. P., and C. G. Vogel. 1978. Agro-Manitoba information package. Lands and Surveys Division, Manitoba Department of Mines, Natural Resources, and Environment. Technical Report 78-9.
- Brander, R. B., and W. W. Cochran. 1969. Radio location telemetry. Pp. 95-103 in *Wildlife management techniques*. Third edition. Edited by R. H. Giles. The Wildlife Society, Washington, D.C.
- Brown, J. L. 1964. The evolution of diversity in avian territorial systems. *Wilson Bulletin* 76: 160-169.
- Brown, J. L., and G. H. Orians. 1970. Spacing patterns in mobile animals. *Annual Review of Ecology and Systematics* 1: 239-262.
- Burt, W. H. 1943. Territoriality and home range concepts as applied to mammals. *Journal of Mammalogy* 24: 346-352.
- Cowan, I. M. 1972. The status and conservation of bears (Ursidae) of the world — 1970. Pp. 345-367 in *Bears — their biology and management*. Edited by S. Herrero. International Union for Conservation of Nature and Natural Resources, Morges, Switzerland. New Series Publication Number 23.
- Crook, J. H. 1970. Social organization and the environment: aspects of contemporary social ethology. *Animal Behaviour* 18: 197-209.
- Crook, J. G., J. E. Ellis, and J. D. Goss-Custard. 1976. Mammalian social systems: structure and function. *Animal Behaviour* 24: 261-274.
- Ewer, R. F. 1973. *The carnivores*. Cornell University Press, Ithaca, New York.
- Garshelis, D. L., and M. R. Pelton. 1981. Movements of black bears in the Great Smoky Mountains National Park. *Journal of Wildlife Management* 45: 912-925.
- Gunson, J. R. 1977. Black bears and beehives in Alberta. *Proceedings of the Western Association of Game and Fish Commissioners* 57: 183-192.
- Hornocker, M. G. 1976. A new look at the mountain lion. *National Wildlife* 14: 42-47.
- Hornocker, M. G., and H. S. Hash. 1981. Ecology of the wolverine in northwestern Montana. *Canadian Journal of Zoology* 59: 1286-1301.
- Jennrich, R. I., and F. B. Turner. 1969. Measurement of non-circular home range. *Journal of Theoretical Biology* 22: 227-237.
- Johnson, K. G., and M. R. Pelton. 1980. Prebaiting and snaring techniques for black bears. *Wildlife Society Bulletin* 8: 46-54.
- Jonkel, C. J., and I. M. Cowan. 1971. The black bear in the spruce-fir forest. *Wildlife Monographs* Number 27.

- Kemp, G. A.** 1976. The dynamics and regulation of black bear (*Ursus americanus*) populations in northern Alberta. Pp. 191–197 in *Bears — their biology and management*. Edited by M. Pelton, J. W. Lentfer and G. E. Folk. International Union for Conservation of Nature and Natural Resources, Morges, Switzerland. New Series Publication 40.
- Mares, M. A., M. R. Willig, and N. A. Bitar.** 1980. Home range size in eastern chipmunks, *Tamias striatus* as a function of number of captures: statistical biases of inadequate sampling. *Journal of Mammalogy* 61: 661–669.
- Messier, F., and C. Barrette.** 1982. The social system of the coyote (*Canis latrans*) in a forested habitat. *Canadian Journal of Zoology* 60: 1743–1753.
- Mohr, C. O.** 1947. Table of equivalent populations of North American small mammals. *American Midland Naturalist* 37: 223–249.
- Reynolds, D. G., and J. J. Beecham.** 1980. Home range activities and reproduction of black bears in west-central Idaho. Pp. 181–190 in *Bears — their biology and management*. Bear Biology Association Conference Series Number 3. Edited by C. J. Martinka and K. L. McArthur. United States Government Printing Office, Washington, D.C.
- Rogers, L. L.** 1977. Social relationships, movements, and population dynamics of black bears in northeastern Minnesota. Ph.D. thesis, University of Minnesota, Minneapolis.
- Steel, R. G. D., and J. H. Torrie.** 1980. Principles and procedures of statistics; a biometrical approach. Second Edition. McGraw-Hill, New York.
- Voigt, D. R., and R. R. Tinline.** 1980. Strategies for analyzing radio tracking data. Pp 387–404 in *A handbook of biotelemetry and radio tracking*. Edited by C. J. Amlaner and D. W. MacDonald. Pergamon Press, Toronto.
- Willey, C. H.** 1974. Aging black bears from first premolar tooth sections. *Journal of Wildlife Management* 38: 97–100.
- Young, B. F., and R. L. Ruff.** 1982. Population dynamics and movements of black bears in east central Alberta. *Journal of Wildlife Management* 46: 845–860.

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Nuisance Grizzly Bear, *Ursus arctos*, Translocations in the Greater Yellowstone Area

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Between 1968 and 1984, 247 nuisance Grizzly Bears (*Ursus arctos*) in the Yellowstone region were translocated 375 times. The number of translocations was highest in 1968 (55) but along with control kills, remained high throughout 1972 following initiation of a new bear management plan in 1970. Only 30% ($N = 3$) of adult females translocated initially without young were with cubs the following year, indicating a negative influence on productivity. Translocations of adult females with young were more successful ($P = 0.07$) in preventing further nuisances (62%, $N = 13$) than for adult females without young (36%, $N = 12$). Fifty-seven percent ($N = 88$) of all individuals moved did not cause another nuisance, and 41% ($N = 35$) did not return to their original capture site. Only 23% ($N = 8$) of translocations over 75 km resulted in the bear's return. Translocations are only partially successful for the Greater Yellowstone Area, so managers should consider other alternatives singly and in combination with translocations to better control nuisance bears.

Key Words: Grizzly Bear, *Ursus arctos*, nuisance, translocation, Yellowstone National Park.

A frequent problem facing Grizzly Bear (*Ursus arctos*) managers is the control of nuisance bears. Typically, nuisances are resolved by removing bears from the site of a nuisance. The objectives of these control actions have been either to prevent a nuisance bear from causing another nuisance or from returning to the original nuisance site. Although this method has its limitations, a more effective solution to the problem of managing nuisance bears has not been forthcoming. Aversive conditioning, conditioning bears to avoid humans, has been studied in a laboratory environment (Hunt 1984), but needs further research to determine its suitability in management situations. Temporary baiting to lure nuisance Grizzly Bears away from problem situations has been found ineffective (M. Haroldson. 1984. Test of temporary baiting of Grizzly Bears. Unpublished report, Interagency Grizzly Bear Study. 15 pp.).

Cowan (1972) suggested that researchers carefully document and publish records of translocations to increase knowledge of the subject. Fourteen years later, however, very few reports have documented the results of translocations for Grizzly and Brown bears (Cole 1972; Craighead and Craighead 1972; Thier and Sizemore 1981; Miller and Ballard 1982), while most have reported results of Black Bear (*Ursus americanus*) translocations (Alt et al. 1977; Beeman and Pelton 1976; Erickson and Petrides 1964; Harger 1967; McArthur 1981; Rogers 1986; Rutherglen and Herbison 1977).

Through 1970, high concentrations of Grizzly Bears near developed areas were caused by open-pit garbage dumps in Yellowstone National Park and surround-

ing communities (Knight and Eberhardt 1985). A new bear management plan initiated by the National Park Service for Yellowstone in 1970 called for the removal of garbage sources, including the closure of the two main Park dumps by 1971, enclosure of incinerator and landfill sites during the 1970s, and installation of bearproof tops on all garbage cans in 1970 (Meagher and Phillips 1983).

These factors combined to reduce the food supplied by humans to grizzlies, contributing to an increased number of nuisances as grizzlies searched for new food sources. Translocations and control kills were necessary to control the nuisance bears. This paper reports the effects and success of Grizzly Bear translocations and control kills in the Greater Yellowstone Area.

Study Area and Methods

The Greater Yellowstone Area includes Yellowstone National Park and portions of adjoining Federal, State, and private lands in Wyoming, Montana, and Idaho (Knight et al. 1978). Vegetation, topography, climate, and fauna of the area are described by Knight et al. (1978). The population of Grizzly Bears in the study area is considered to be relatively low (Knight and Eberhardt 1985) compared to other populations in North America.

Data on the translocation and control kills of nuisance Grizzly Bears and on their history were obtained from the records of agencies involved in Grizzly Bear management in the Greater Yellowstone Area. These data were compiled for the period 1968 through 1984 and include 375 translocations of 247

nuisance. Grizzly Bears. Records prior to 1971 were incomplete and success of the translocations could not be determined from them. Therefore, my analyses of the effects and success of these translocations are confined to the period from 1971 through 1984 during which 154 individual bears were translocated 225 times. However, seven of these bears were known to have been first translocated prior to 1971 so these translocations were included in the analyses for a total of 232.

Through 1974 there were 12 bears included in the analyses which were not classified by sex and one which was not classified by age, thus necessitating their exclusion from analyses for sex or age differences.

The result of a translocation was known for 139 of the 232 translocations analyzed. Because a few nuisances were recorded in which the identity of the nuisance bear was not known and control actions either were not possible or were not initiated, the remaining 93 translocations were not analyzed to determine success for preventing return or further nuisances.

The date(s) of a bear's subsequent nuisance activity was considered to be the date the bear was recaptured after causing a nuisance. Some nuisance activities may have occurred before the recapture dates, but either the bear was not captured or the incident did not warrant translocation. A translocation was considered successful in preventing return if the bear moved was recaptured in a different location or was not recaptured or observed in the original capture area. However, it is possible that some translocated bears returned without being recaptured as most were not radio-instrumented. Miller and Ballard (1982) considered translocated bears as returned if they were located within 1.2 times the average home range diameter of their capture sites, or if they made nondirectional movements suggesting that they were in familiar territory. Translocations were considered successful in preventing further nuisances if the bears were known not to have caused another nuisance.

Differences between means were tested using Analysis of Variance (ANOVA). Differences between proportions were tested using Chi-square analysis. All data were analyzed using Statistical Analysis Systems (SAS) and MSUSTAT (Lund 1985) computer software.

Results and Discussion

Temporal Pattern of the Translocations

Translocations ranged from a high of 55 in 1968 to one each in 1978 and 1979 (Figure 1). Craighead and Craighead (1972) reported that 51 marked and unmarked bears not previously captured in

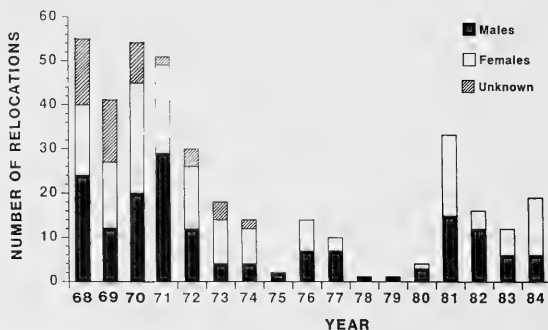


FIGURE 1. Number of Grizzly Bear translocations by sex, Greater Yellowstone Area, 1968-1984.

campgrounds or developed areas were captured in these areas following reduction in the amount of garbage disposed of at one of the two main Park dumps in 1968. These two dumps and one municipal dump outside the Park were closed by 1971 because of their influence on Grizzly Bears. These actions caused a severe reduction in food sources previously available to Grizzly Bears and resulted in an increased number of nuisances which required a high number of control actions from 1968 through 1972. Control actions during this four year period accounted for 62% ($N = 231$) of all controls from 1968 through 1984.

Because bears began adjusting to a new food regime and because control kills in previous years probably reduced the population (Craighead et al. 1974), a lower level of control actions were required during the mid-1970s. Craighead and Craighead (1972) indicated that Grizzlies dispersed widely following closure of one of the Park's main dumps in 1970. A comparison of average home range sizes reported by Craighead (1976) [134 km^2] and Knight et al. (1982) [643 km^2] indicate that Grizzly Bear home ranges were approximately five times larger after the initiation of the Park's new bear management plan and the dump closures. Nuisances outside the Park boundary (Table 1) increased in the late 1970s as bears found human food sources there.

Translocations rose to a high level again in 1981 (Figure 1) with the majority of the nuisances occurring outside the Park boundary (Table 1). Knight et al. (1982) reported that the high frequency of observations of Grizzly Bears around human habitation in 1981 was due to a shortage of natural foods beginning in the fall of 1980 and continuing through 1981.

Effect of Translocation on Grizzlies

Nuisance bears often have to be controlled by destroying them. Control mortalities (including removals to zoos) between 1969 and 1984 among the 247 nuisance bears totaled 49 (Figure 2). These

TABLE 1. Number of translocations of nuisance Grizzly Bears relative to the Yellowstone National Park boundary, Greater Yellowstone Area, 1968-1984.

Nuisance site to release site	Year																	Totals
	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	
Within park	55	41	54	31	22	10	12		14	8		1	3	7	4	2	8	272
Outside to park				1	4	3							1	20	11	9	11	60
Park to outside				3														3
Outside to outside				16	4	5	2	2		2	1			6	1	1		40
Totals	55	41	54	51	30	18	14	2	14	10	1	1	4	33	16	12	19	375

included 39 control deaths, six removals to zoos, and four accidental deaths. Mortalities of Yellowstone grizzlies were high through 1972 due primarily to the control deaths of recurring nuisance bears. For example, Greer (1972) reported that of 17 grizzlies translocated because of nuisances at the West Yellowstone municipal dump in 1971, only three (18%) were not known to have been killed the same year.

Control mortalities were lower during the rest of the 1970s but rose again in 1982 following the high number of translocations in 1981 (Figure 1). Mortalities are more likely related to a translocated bear's habituation to food supplied by humans than to circumstances of the translocation. Of 48 control removals among the 247 individuals translocated, only four (8%) were due to accidents during the translocation. Forty-four (92%) were control removals of recurring nuisance bears. Further, the detection of mortality has been easier in recent years because most translocated bears have been radio-instrumented.

There were 57 translocations of 31 adult female grizzlies (≥ 5.5 years old) between 1971 and 1984. Only three of 10 reproductive age females without young, in which the reproductive status was known one year after their translocation, had cubs the next year. This finding indicates that translocating adult females may influence their productivity the year following a translocation. Adult females without young one year could be expected to produce cubs the following year. Miller and Ballard (1982) suggested that trauma associated with translocation, homing, or establishment of a new home range may result in lowered productivity for Alaskan Brown Bears.

Success of Translocations

Of 154 grizzlies translocated between 1971 and 1984, 49 (32%) were translocated twice, 18 (12%) three times, and 11 (7%) four or more times (Table 2). Seventeen additional individuals were destroyed for control purposes after their second nuisance, 10 after

their third, four after their fourth, and five after five or more nuisances. Therefore, 43% ($N = 66$) were known to have caused another nuisance (A success rate of 57% in preventing further nuisances) and 24% ($N = 37$) caused more than two nuisances. The success rate after the second nuisance (29%) drops to almost half that after the first (Table 2), indicating that if a bear causes a nuisance again after its first translocation, it has become an habitual nuisance bear. The success rate for preventing further nuisances in Black Bears ranged from 63-76% (Alt et al. 1977; Rutherglen and Herbison 1977; Harms 1980). Thier and Sizemore's (1981) data indicate a 65% success rate in preventing further nuisances for Grizzly Bears in northwestern Montana.

Of 104 nuisances subsequent to a translocation, 80% ($N = 83$) occurred within one year and 90% ($N = 94$) within 14 months. It is apparent then that if an individual is going to cause another nuisance following a translocation, it is most likely to do so within 14 months. Alt (1980) reported that quite often a nuisance subsequent to a translocation involved a different type of problem and occurred two or more years after the original problem. Results from the

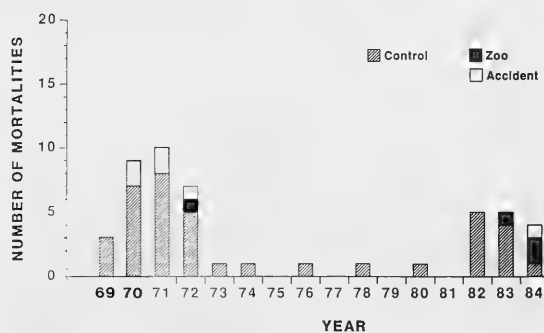


FIGURE 2. Control mortalities and removals of previously translocated Grizzly Bears in the Greater Yellowstone Area, 1969-1984.

TABLE 2. Outcome of Grizzly Bear translocations for each translocation number, Greater Yellowstone Area, 1971-1984.

Translocation Outcome	Number of translocations				Totals
	1	2	3	4 or more	
Nuisance again	75 (49%) ^a	35 (71%)	12 (67%)	7 (64%)	129
No further nuisances	79	14	6	4	103
Totals	154	49	18	11	232
Return to capture site ^b	50 (59%)	18 (55%)	7 (54%)	4 (50%)	79
No return ^b	35	15	6	4	60
Totals	85	33	13	8	139

^aNumber in parentheses indicates percent causing further nuisances or returning.

^bNumber out of total known to have returned or not.

present analysis show that of the 12 subsequent nuisances occurring 14 or more months later, five involved the same type of problem. Grizzlies are known to respond to conditioning by remembering what activities are rewarded or result in obtaining food (McCullough 1982).

For grizzlies in Yellowstone there was no difference ($P = 0.22$) between age of repeating ($\bar{x} = 4.4$ years old) and nonrepeating ($\bar{x} = 3.4$ years old) nuisance bears. Also, subadults (< 5.5 years old) caused subsequent nuisances at the same ($X^2 = 0.24$, $P = 0.63$) rate (44%, $N = 54$) as adults (≥ 5.5 years old) (47%, $N = 48$).

For 135 individuals of all ages classified by sex there was no difference ($X^2 = 0.29$, $P = 0.59$) between sexes in preventing further nuisances [44% ($N = 31$) success for males, 39% ($N = 64$) for females]. However, females ($\bar{x} = 5.2$ years old) were older ($P = 0.01$) than males ($\bar{x} = 3.1$ years old). Adults showed no difference ($X^2 = 1.47$, $P = 0.23$) between sexes in the rate of subsequent nuisances. Subadult males caused subsequent nuisances more ($X^2 = 3.67$, $P = 0.056$) often (47%, $N = 18$) than subadult females (26%, $N = 9$).

The fact that in the Greater Yellowstone Area a grizzly in any location may be no more than approximately 43 km from a developed area probably

explains why there is no difference ($X^2 = 0.97$, $P = 0.91$) among distance categories in the number of bears causing another nuisance and not (Table 3). Considering that the average size of a home range for a Yellowstone grizzly is 643 km² (Knight et al. 1982), it is not likely that such a short distance would prevent a translocated bear from returning to the original nuisance site or from moving to a closer developed area and causing another nuisance. There was no difference ($P = 0.25$) in distance moved between bears repeating a nuisance ($\bar{x} = 35$ km) and nonrepeating bears ($\bar{x} = 38$ km).

Of the 154 bears in this analysis, the fate of 85 was known. Of these, 35 bears did not return to their capture area for a success rate of 41% in preventing returns (Table 2). Craighead and Craighead (1972) reported a success rate of only 32% in preventing return to any campground or developed area. A success rate of 59% is indicated from Thier and Sizemore's (1981) data on Grizzly Bears moved a mean of 99 km. However, 41% of their bears were not observed again after release or were lost within 14 months. For Black Bears, success rates ranged from 31% to 46% for maximum translocation distances of less than 50 km up to 117 km (Harger 1967; Beeman and Pelton 1976; Alt et al. 1977; Rutherglen and

TABLE 3. Outcome of Grizzly Bear translocations for 25 km translocations distance categories, Greater Yellowstone Area, 1971-1984.

Translocation Outcome	Distance categories					Totals
	1-25	25-50	50-75	75-100	100-125	
Nuisance again	8 (47) ^a	39 (49)	28 (42)	18 (47)	9 (41)	102 (46)
No further nuisances	9 (53)	41 (51)	39 (58)	20 (53)	13 (59)	122 (54)
Totals	17	80	67	38	22	224
Return to capture site	8 (62)	37 (79)	22 (59)	4 (21)	4 (33)	75 (57)
No return	5 (38)	10 (21)	15 (41)	19 (79)	8 (67)	57 (43)
Totals	13	47	37	23	12	132

^aNumber in parentheses represents the column percent.

Herbison 1977; McArthur 1981). Rogers (1986) reported that Black Bears must be moved greater than 64 km to assure that less than 50% return. Miller and Ballard (1982) reported a success rate of 40% for Alaskan Brown Bears moved 145–286 km (\bar{x} = 216 km). One hundred sixty-nine (73%) of the first time translocations in the present analysis were less than 70 km in distance, 61 (78%) subsequent translocations were less than 70 km, and the greatest translocation distance was 121 km.

Craighead and Craighead (1972) stated that the percentage of translocated grizzlies returning decreased as the distance moved increased. In the present analysis, nuisance bears returning to their original capture sites had been moved a shorter distance (\bar{x} = 30 km P < 0.0001) than nonreturning bears (\bar{x} = 42 km).

There appears to be a distance threshold beyond which a bear is less likely to return. Whereas 69% (N = 67) of the translocations less than 75 km resulted in return, 77% (N = 27) of those over 75 km resulted in no return (Table 3). Miller and Ballard (1982) reported that there probably was a distance threshold beyond which Brown Bears would not return but that it was over 258 km.

In 131 translocations classified by sex and by whether the bear returned to the capture site or not, more (X^2 = 5.9, P = 0.02) females (68%, N = 40) returned than males (47%, N = 34). However, females (\bar{x} = 6.6 years old) were older (P = 0.004) than males (\bar{x} = 3.3 years old). For adults (X^2 = 2.31, P = 0.13) and subadults (X^2 = 0.11, P = 0.74) there was no difference in return rate between sexes. Females returned (N = 40) more often (X^2 = 6.78, P = 0.009) than not (N = 19). McArthur (1981) reported that female Black Bears are more highly motivated to return than males.

For all ages combined, males were moved the same distance (\bar{x} = 37.4 km, P = 0.13) as females (\bar{x} = 33.2 km). For adults, males were moved a greater (\bar{x} = 40.8 km, P = 0.03) distance than females (\bar{x} = 33.8 km). Subadults of both sexes were moved the same (P = 0.44) distance. Returning bears were older (\bar{x} = 6.0 years old) than nonreturning bears (\bar{x} = 3.3 years old, P = 0.02), and adults returned (73%, N = 43) more often (X^2 = 11.22, P = 0.0008) than subadults (44%, N = 32). Returning females (\bar{x} = 8.8 years old) were older (P = 0.02) than nonreturning females (\bar{x} = 3.9 years old), and returning females (\bar{x} = 31.0 km) were moved a shorter (P = 0.096) distance than nonreturning females (\bar{x} = 37.7 km).

These differences probably explain why females return more often than not. Older bears are more likely to return because of a higher fidelity for their

home range. Also, grizzlies are known to make excursions from their home range and their life range is considerably larger than their annual home range. Both of these factors allow the grizzly to be familiar with a large area and may facilitate return by improving a bear's ability to orient itself after a translocation. It would be expected that bears moved a shorter distance would be more likely to return. There was no difference between sexes in the number of returning and nonreturning bears reported by Miller and Ballard (1982) for Brown Bears, or for Black Bears by Beeman and Pelton (1976) or Harms (1980). McArthur (1981) suggested that female Black Bears are more highly motivated to return than males because males have larger home ranges but do not return more often than females.

The findings from this and other analyses indicate that translocation may be a relatively successful management practice for preventing returns by Yellowstone grizzlies. However, with respect to the management objective of preventing returns, the 41% success rate must be considered low.

There was no significant difference (X^2 = 0.93, P = 0.34) in return rate for adult females without young (92%) (N = 22) and with young (80%) (N = 8). Because familiarity with their home range would help them meet their greater resource needs, more females with young might be expected to return than those without, if moved an equal distance. Females with young (\bar{x} = 35 km) and without young (\bar{x} = 36 km) were moved the same (P = 0.69) distance. Adult females with young were less likely (X^2 = 3.37, P = 0.07) to cause a nuisance after being moved (38%, N = 8) than were adult females without young (64%, N = 21). Perhaps females with young, to protect them, avoid human interaction more than females without young.

Fifty-four young bears (\leq 2.5 years old) were translocated 77 times. Sixteen (30%) were translocated at least twice, and only five (9%) were translocated three or more times. Miller and Ballard (1982), Harms (1980), Alt et al. (1977), and Harger (1967) indicated that young bears are less likely to return or to repeat a nuisance because they lack a homing ability, have no desire to return, or because of higher mortality than other age classes.

Thirty-seven young were translocated 44 times in association with a nuisance their mother caused. Only 16% (N = 6) were moved two or more times and only one was moved three or more times. In addition, only five (14%) of these 37 bears were recorded as having caused a nuisance again without their mothers. Of 17 young without their mothers, 10 (59%) were moved at least twice and four (24%) more than twice. Translocations of young which caused a nuisance with

their mothers, were more successful (84%) ($X^2 = 8.20$, $P < 0.005$) than translocations of young which caused a nuisance without their mothers (41%). Young without their mothers, either because they had been abandoned, weaned, or their mothers died, would be expected to cause more nuisances if they were older than cubs and were, therefore, able to learn that sources of food supplied by humans were easier to acquire. Young without their mothers ($x = 1.27$ years old) were older ($P < 0.0001$) than those with their mothers $x = 0.7$ years old).

Conclusions

Translocation of nuisance grizzlies should continue to be used by managers until more effective alternatives can be developed. Considering the objectives and the relative economic costs, the success rate in the Greater Yellowstone area of 57% for prevention of further nuisances and 41% for prevention of returns must be considered low even if socially acceptable. The success of translocations can probably be improved by consideration of the release habitat by season and selecting those sites with features most important to the bear, always considering the proximity of the new site to nuisance stimuli and other potential conflicts. Alternative methods, direct (i.e. control kills or removal to a zoo) or indirect (i.e. prevention through management of foods supplied by humans or through aversive conditioning) either reduce the population or are unproven or ineffective in controlling a nuisance after its occurrence.

However, translocation is not appropriate in all nuisance situations nor for all bears. Considering that some individuals (older bears, and those with a history of more than one nuisance) have a high probability of causing subsequent nuisances or returning, managers should consider their immediate removal following a nuisance. It is inappropriate to overprotect individuals through repeated translocations and leaving high risk individuals in the population may increase the probability of serious incidents, thereby damaging the grizzly in the public's eye, and in the long run may place pressure on the grizzly population.

Other alternatives include the use of aversive conditioning of nuisance bears, particularly in conjunction with a translocation. Methods successful in holding a translocated bear at the release site should be explored. Although impractical, the best solution would be the removal of all bear attractants which create the nuisance bear situation. However, further reduction of these attractions is possible and should be more seriously considered.

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Literature Cited

- Alt, G. L. 1980. Relocating nuisance bears. *Pennsylvania Game News* 51(3): 20-22.
- Alt, G. L., G. J. Matula, Jr., F. W. Alt, and J. S. Lindzey. 1977. Movements of translocated nuisance Black Bears of northeastern Pennsylvania. *Transactions of the Northeast Fish and Wildlife Conference* 34: 119-126.
- Beeman, L. E., and M. R. Pelton. 1976. Homing of Black Bears in the Great Smoky Mountains National Park. *International Conference on Bear Research and Management* 3: 87-95.
- Cole, G. F. 1972. Preservation and management of Grizzly Bears in Yellowstone National Park. *International Conference on Bear Research and Management* 2: 274-288.
- Cowan, I. M. 1972. The status and conservation of bears (Ursidae) of the world — 1970. *International Conference on Bear Research and Management* 2: 343-367.
- Craighead, F. C. 1976. Grizzly Bear ranges and movement as determined by radio-tracking. *International Conference on Bear Research and Management* 3: 97-109.
- Craighead, J. J., and F. C. Craighead, Jr. 1972. Grizzly Bear-man relationships in Yellowstone National Park. *International Conference on Bear Research and Management* 2: 304-332.
- Craighead, J. J., F. C. Craighead, and H. E. McCutcheon. 1970. Age determination of Grizzly Bears from fourth premolar tooth sections. *Journal of Wildlife Management* 34: 353-363.
- Craighead, J. J., J. R. Varney, and F. C. Craighead, Jr. 1974. A population analysis of the Yellowstone Grizzly Bears. *Montana Forest and Conservation Experiment Station, School of Forestry. Bulletin* 40. 20 pp.
- Erickson, A. W., and G. A. Petrides. 1964. Population structure, movements, and mortality of tagged Black Bears in Michigan. Pages 46-67 *in* The Black Bear in Michigan. Edited by A. W. Erickson, J. Nellor, and G. A. Petrides. Michigan Agricultural Experiment Station Research Bulletin 4.

- Greer, K. R.** 1972. Grizzly Bear mortality and management programs in Montana during 1971. Federal Aid in Wildlife Restoration, Job Completion Report Project W-120-R-3, Number L-1.1. Montana Department of Fish and Game, Helena. 44 pp.
- Harger, E. M.** 1967. Homing behavior of Black Bears. Michigan Department of Conservation Research and Development Report 118. 13 pp.
- Harms, D. R.** 1980. Black Bear management in Yosemite National Park. International Conference on Bear Research and Management 4: 205-212.
- Hunt, C. L.** 1984. Behavioral responses of bears to tests of repellants, deterrents, and aversive conditioning. M.Sc. thesis, University of Montana, Missoula. 139 pp.
- Knight, R. R., J. Basile, K. Greer, S. Judd, L. Oldenburg, and L. Roop.** 1978. Yellowstone Grizzly Bear investigations: Annual report of the Interagency Study Team 1977. United States Department of Interior, National Park Service. 107 pp.
- Knight, R. R., B. M. Blanchard, and K. C. Kendall.** 1982. Yellowstone Grizzly Bear investigations: Annual report of the Interagency Study Team 1981. United States Department of Interior, National Park Service. 70 pp.
- Knight, R. R., and L. L. Eberhardt.** 1985. Population dynamics of Yellowstone Grizzly Bears. Ecology 66 (2): 323-334.
- Lund, R. E.** 1985. MSUSTAT: An interactive statistical analysis package. Research and Development Institute, Montana State University, Bozeman. 146 pp.
- McArthur, K. L.** 1981. Factors contributing to effectiveness of Black Bear transplants. Journal of Wildlife Management 45: 102-110.
- McCullough, D. R.** 1982. Behavior, bears and humans. Wildlife Society Bulletin 10: 27-33.
- Meagher, M., and J. R. Phillips.** 1983. Restoration of natural populations of Grizzly and Black Bears in Yellowstone National Park. International Conference on Bear Research and Management 5: 152-158.
- Miller, S. D., and W. B. Ballard.** 1982. Homing of transplanted Alaskan Brown Bears. Journal Wildlife Management 46: 869-876.
- Rogers, L. L.** 1986. Effects of translocation distance on frequency of return by adult Black Bears. Wildlife Society Bulletin 14: 76-80.
- Rutherglen, R. A., and B. Herbison.** 1977. Movements of nuisance Black Bears (*Ursus americanus*) in southeastern British Columbia. Canadian Field-Naturalist 91: 419-422.
- Thier, R., and D. Sizemore.** 1981. An evaluation of grizzly relocations in the BGP area, 1975-1980. Border Grizzly Project Special Report Number 47. 17 pp.

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A Possible Method for Estimating River Otter, *Lutra canadensis*, Populations Using Snow Tracks

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A possible method for estimating the size of a River Otter, *Lutra canadensis*, population is described. The various potential sampling errors which might result from misinterpretation of snow tracks and other survey characteristics are described. The relative advantages and disadvantages of the proposed technique are compared with those of other population estimation techniques for River Otters which use sign surveys, scent attractant with track boards, or radioactive labelling of individual otters. The use of snow tracks as a population estimation technique would be the least expensive but still requires substantial manpower to achieve population estimates with reasonable precision.

Key Words: River Otter, *Lutra canadensis*, population density, snow tracks, Alberta.

Techniques for estimating population size of free-ranging furbearers are difficult to derive and implement. Historically, managers have relied on trends in fur-harvest data from commercial trappers or on species-specific indices, such as active Beaver, *Castor canadensis*, lodges in autumn (Hay 1958) or visits to scent stations by Coyotes, *Canis latrans* (Linhart and Knowlton 1975).

River Otters, *Lutra canadensis*, are harvested annually in many parts of North America, but their semi-aquatic habits and relatively low densities in many habitats make a direct census impractical. Researchers have addressed the need to produce a reliable and rigorous estimation technique by using sign left by otters. Knaus et al. (1983) found that radioactive ⁶⁵Zn could be detected in labelled scats of captive otters for up to 215 days, and proposed applying the technique to a wild population. Humphrey and Zinn (1982) proposed the use of line transects of chalk-dusted trackboards, each with a scent attractant, to record tracks of otters attracted to the scent. In testing this technique in Florida, Robson (1982) and Robson and Humphrey (1985) concluded that the technique was insufficiently sensitive because otters became habituated to the scents offered or were reluctant to step on trackboards.

Surveys of otter sign (scats and scent mounds) along stream and lake shores can provide relative estimates of otter abundance (MacDonald and Mason 1985; Jenkins and Burrows 1980), but have not yet been developed with statistical rigour. Robson (1982) concluded that a statistically rigorous technique for measuring relative abundance,

contingent on understanding the effects of age, sex, density, and season on defecation and scent-marking behaviours, could be developed from sign surveys.

Over much of their range in Canada, River Otters live in a seasonal climate with winter snow in which they leave distinctive tracks. Otters are harvested in nearly all jurisdictions, but estimates of abundance are still based on fur-harvest data (Boyd 1977) with their inherent biases. Researchers have not indexed population size using snow tracks, yet snow tracks appear to offer some advantages over other sign. Any otter, no matter what sex or age, will produce tracks when moving above ground in winter, whereas the incidence of scats and scent mounds may vary with sex or age-class in different seasons. Snow tracks are a continuous type of sign of measurable dimensions, such that independence of otter activity at different locations can be discerned by following tracks and identifying individual animals within groups by their unique sign.

This paper outlines the development and initial field testing of a technique for estimating the population density of otters by using tracks left in snow. This experimental research took place as part of a long-term study of River Otter ecology in northeastern Alberta.

Study Area

The study area, surrounding Winefred Lake (55°30'N, 110°30'W), was chosen for its relatively high density of River Otters (Boyd 1977). The physiography is characterized by low relief and no outcropping bedrock, and the area has a surficial

geology of outwash and lacustrine glacial deposits. Drainage channels vary from indistinct muskeg channels (subsurface drainage) to the Winefred River (10–15 m wide). Lakes vary from shallow, eutrophic bog ponds, often without surficial drainage, to large eutrophic (Winefred Lake) and oligotrophic (Grist Lake) lakes.

The terrestrial surface area of catchments through which surveyed streams flowed was 345 km². The surface area of lakes falling inside these catchments was 121 km², including 96 km² on Winefred Lake alone. Streams of different orders (Strahler 1969: 483) were found in the following total lengths: first order — 66.0 km, second order — 19.5 km, third order — 8.5 km, and fourth order — 32.0 km, giving a total of 126.0 km. Total shoreline length of lakes was 124.0 km, of which 41.0 km were on Winefred Lake, 12.5 km on Grist Lake, and 70.5 km on a combination of many much smaller and generally eutrophic lakes and ponds.

The climate and vegetation are typical of the boreal mixed-wood forest (Rowe 1972; Strong and Leggat 1981). Winters are dry (1170 mm snow from October to April) and cold (mean temperature from December to February of -15.5°C). Summers are moist (320 mm rain) and warm (mean temperature from May to September of 12°C). Snow cover is continuous for an average of 150 days and accumulates to a mean maximum thickness of 50 cm. Mean maximum and minimum daily temperatures between 1 and 6 December 1983 were -11.0°C and -19.0°C, respectively. Daily temperatures were not recorded in 1984.

The study area supports a wide variety of boreal animals. Of special importance to otters are populations of cyprinid, gasterosteid, esocid, catostomid and salmonid fishes (Paetz and Nelson 1970; Gilbert and Nancekivell 1982). The density of Beavers is similar to that in other southern boreal areas (Reid 1984). Two other semi-aquatic mammals, Mink, *Mustela vison*, and Muskrat, *Ondatra zibethicus*, are not common (Boyd 1977).

This area includes no year-round public road access or permanent human settlements except for two natural gas processing plants and two tourist fishing lodges. Commercial fur trapping took place on three of five registered traplines during the study.

Materials and Methods

Development of the Technique

General observations of otter sign and evidence from radio-telemetry (Reid 1984) revealed patterns which were important in designing a survey technique. Otters may forage underwater hundreds of metres from shore, but with ice cover, they must return to

shore to breathe and to move above ground. All winter dens were located on shorelines within 10 m of water. When travelling in terrestrial habitats between water bodies, otters generally took straight-line routes to destination shorelines where water access was assured. Otter habitat was therefore considered to be linear and composed of shorelines.

A shoreline segment length of 500 m was chosen as the unit for sampling the expected, clumped distribution. It was a length which, judging by our observations over previous winters, incorporated most of the daily activity of an individual or group of otters, with very little chance of encountering another independent group of otters in the same segment on the same day. In addition, 500 m was a convenient length when confronted with the problem of surveying a sufficient number of segments in as short a time as possible.

To use snow tracks as a direct measure of the number of otters on a shoreline segment, two conditions must be met: (i) that there be sufficient snow of good quality to record the passage of otters, and (ii) that all otters resident in a segment move above ground at some time during the day (i.e., temperatures are not so cold as to preclude movement or defecation above ground). Ideally, all water bodies should be ice-covered, thereby increasing the snow-covered area on which otters can make tracks to indicate presence and group size.

These conditions can only be met in our study area during a relatively short period of time in early winter, usually the last week in November and the first ten days of December. This is the period between the first substantial snowfall and the onset of very cold weather. Sampling cannot proceed without snow, but a test of whether the second condition can be met at this time of year was made by following radio-instrumented otters. Otters were live-captured, instrumented and telemetered for other study objectives as described by Reid (1984). In December 1983, all 11 radio-instrumented otters moved above ground during the sampling period.

Otters may be found individually or in small groups of variable composition at any time of year (Melquist and Hornocker 1983). The number of otters on a sample segment can be determined from snow tracks. However, the presence of otters is a relatively rare phenomenon, so that many sample segments can be expected to have no otter tracks present, and very few will have tracks of more than two otters present. These results suggest that presence of otters on the segments may be described by a Poisson distribution. The population estimate is the mean number of animals, determined from observed tracks in the sampled segments, extrapolated across all segments in the study area.

TABLE 1. Frequency and mean number of otter tracks in 0.5-km intervals, and approximate 95% confidence limits for true population ($N\theta$) of otters in 250 km of otter habitat in northeastern Alberta.

Year	Total segments	Sample size n	Frequency of tracks			Sample mean θ	Estimated population $N\theta$	Approximate confidence limits (95%)
	N		0	1	2			
1983	500	60	56	2	2	0.100	50	$18 < N\theta < 109$
1984	500	55	51	4	0	0.073	36	$9 < N\theta < 93$
Both Years	500	115	107	6	2	0.087	44	$20 < N\theta < 80$

Application of the Technique

The shorelines of all lakes and water courses shown on 1:50 000 N.T.S. mapsheets were divided into numbered, 500-m-long segments. Numbering was initiated at creek or river mouths and proceeded upstream along the main channel. Segments were then numbered progressively upstream on each tributary and its tributaries. Shoreline segments on lakes were numbered counter-clockwise from the overflow if the entire lake fell within the study area, and in both directions from a major river mouth if part of the shoreline fell outside the area. Excess shoreline segments less than 500 m long, whether at the head of tributaries or on lakes, were amalgamated into 500-m lengths and jointly numbered. Both banks of a stream or river were included in the segment if the water course was less than 20 m wide. Wider water courses, though very rare in the study area, were sampled with separate segments along each bank.

A total of 500 segments representing 250 km of shoreline were numbered. Two random samples (independent and with replacement) of numbered segments were selected for survey over seven-day periods in each of two winters, with 60 segments surveyed 1-6 December 1983 and 55 segments surveyed 5-11 December 1984. Each segment was searched on foot for otter sign, which was estimated to be either less than or more than 24 hours old, judging by snow and hoar frost in the tracks and whether or not the scats had frozen. Only otter sign believed to be less than 24 hours old at the time of the survey was tallied. Characteristics of all observed sign, including estimated age of tracks and size and composition of otter groups, were also recorded. The longer the survey period, the greater the chance that otter sign on separate segments would not be independent. This eventuality was frequently checked by following tracks through adjacent, non-sampled segments to ensure that they were not tallied twice, and by comparing furrow widths of otter tracks on closely spaced segments.

In addition to conventional statistical methods, we used the Kolmogorov-Smirnov two-sample test

(Siegel 1956) to test for agreement between the two samples. The distribution of the combined sample values was tested for agreement with a theoretical Poisson distribution with mean equal to the combined sample mean using the Kolmogorov-Smirnov one-sample test (Siegel 1956). Confidence intervals for estimating the true population mean were calculated using upper and lower limit factors for the Poisson distribution given by N. Mantel, reproduced in Johnson and Kotz (1969: 97, Table 1).

We calculated sample sizes necessary for estimating the density of otters to within $\pm 20\%$ and $\pm 10\%$ of the true density with 95% confidence using the formula for the normal approximation to the Poisson distribution given by Johnson and Kotz (1969: 96, formula 30). The upper limit factors calculated using this formula had close correspondence to the upper limit factors in Johnson and Kotz (1969: 97, Table 1) for infinite populations. Therefore, we used the upper interval only in calculating sample sizes. To reduce the size of samples required to obtain the desired levels of precision of estimation, we assumed sampling without replacement and corrected the formula for finite population (Snedecor and Cochran 1980: 439).

Results

Most segments contained no otter tracks, and none contained tracks of more than two otters. The sample means (θ) for 1983 and 1984 were 0.100 and 0.073 otters per segment, respectively, and the combined mean was 0.087 otters per segment, with a total population estimate of 44 otters (Table 1). The Kolmogorov-Smirnov two-sample test showed no difference ($P > 0.05$) between the two annual samples, and the Kolmogorov-Smirnov one-sample test showed no difference ($P > 0.05$) between the combined sample distribution and the theoretical Poisson distribution with mean 0.087. The approximate 95% confidence limits for each of the annual samples and the combined sample are shown in Table 1. The sample sizes and sampling intensity required to achieve the specified precision of estimation are shown in Table 2.

TABLE 2. Sample sizes and sampling intensity required for interval estimation (95%) of true population density (Θ) of otters in 250 km of otter habitat in northeastern Alberta.

Precision of estimation	Sample size (500-m segments)	Sampling intensity
$\Theta \pm 20\%$	364	72.8%
$\Theta \pm 10\%$	454	90.8%

Discussion

Our population estimate of 44 otters has a very wide confidence interval, even for the relatively high sampling intensity (23% for the combined sample). This illustrates the central problem in estimating populations with low densities: estimates with reasonable precision can only be achieved with very intensive sampling. We were unable to verify this population estimate directly, but from observation of otter sign and radio-instrumented otters over four years of study, we believe the estimate to be reasonable and within the calculated confidence interval.

Because sampling must take place on the ground and often in terrain of difficult access, and because it should take place within a short period of time (approximately one week), the proposed technique is labour-intensive. In this study area two observers sampled an average of five segments each per day, giving a sampling intensity of 10 to 15%. With more intensive sampling, sample segments would be less dispersed and travel time per sampling unit reduced, thereby allowing more efficient sampling.

The reliability of the population estimate is subject to several potential sampling errors. Misinterpretation of tracks could result in underestimation or overestimation. For example, an observer may not be able to assess the number of otters using a short stretch of repeatedly-used trail from den entrance to latrine. A search for other tracks coming to points of water access either within the same segment or in adjacent segments will be necessary. Otters may travel in a line, making a single furrow, or may travel in different directions along the same route. To avoid error, an observer must carefully scrutinize and follow tracks beyond the limits of the segment and identify individual otters by measuring furrow widths where possible.

The second potential sampling error is built into the maximum allowable lag (24 hours) between tracks being made and observed. If the otter(s) have moved off the segment and the sign is tallied, an overestimate will result.

The third potential sampling error occurs when otters are present without leaving above-ground sign

because they have reached a den site on the segment by travelling through open water or under the ice. An underestimate will result. This potential error may vary with ambient temperature and can be minimized by ensuring that the survey takes place in early winter before temperatures become excessively cold, and before water draw-down in beaver ponds creates air cavities under the ice (Reid 1984). In general, the second and third potential errors will work to counteract each other, but sampling errors, when considered together, are most likely to produce an underestimate of the population density.

A potential statistical error is the possibility that sample segments may not be independent. When sign found on one segment is similar in type (furrow width and group size) and age to that on a nearby segment, observers must check that the sign was not made by the same otters. They may have to survey intervening segments even though these were not chosen as sample segments.

The technique of using snow tracks can give an absolute estimate of population size. Other techniques, which rely on scats or visits to scent stations, require considerable refinement to determine the effect of age, sex and season on the observed sign before they can produce relative or absolute population estimates (Robson 1982). Each technique has advantages or disadvantages in terms of other criteria (Table 3). Snow tracks provide a relatively cheap technique because little equipment is required and observers need visit the study area only once. However, this technique can only be used in northern portions of otter range. The exact timing of its application will vary with latitude, depending on the onset of winter.

The estimated density can be expressed in terms of individuals per linear length of shoreline, or of individuals per unit area of land surface falling within the catchment area of the drainages sampled. We suggest recording both statistics, and also providing measures of the length of different shoreline types (e.g., first-, second- and third-order streams, lakes, ponds etc.) found in a study area. These statistics are important in comparing population estimates from different study areas which may vary considerably in their aquatic community composition.

This technique has given an estimate of total numbers along unstratified lengths of stream and lake shores. However, it is likely that otters show seasonal preferences for certain water bodies or shoreline types in response to changing food availability and ice cover (Melquist and Hornocker 1983). When this study was initiated, such preferences were unclear for the boreal ecosystem, but are expected to be clarified through analysis of the radio-telemetry data (Reid 1984). This

TABLE 3. Comparison of the utility of various population estimation techniques.

Technique	Criteria			
	Handling animals	Equipment*	Field effort	Application across range
Snow tracks	Not required	Insignificant	Extensive labour — one visit	Limited to northern distribution
Scent and track boards	Not required	Elaborate (chalkboards and scent)	Extensive labour — multiple visits	Possible
Radio isotope	Required	Elaborate (scintillation counter)	Extensive labour — multiple visits	Possible

*Equipment normally not available within the area.

estimation technique will likely benefit both in accuracy and in reduction of sampling effort by stratified sampling of shoreline types.

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Literature Cited

Boyd, M. 1970. Analysis of fur production records by individual fur-bearing species for registered trapping areas in Alberta, 1970-75. Alberta Energy and Natural Resources, Fish and Wildlife Division. Edmonton. 72 pp.

Gilbert, F. F., and E. G. Nancekivell. 1982. Food habits of mink (*Mustela vison*) and otter (*Lutra canadensis*) in northeastern Alberta. Canadian Journal of Zoology 60: 1282-1288.

Hay, K. G. 1958. Beaver census methods in the Rocky Mountain region. Journal of Wildlife Management 22: 395-402.

Humphrey, S. R., and T. L. Zinn. 1982. Seasonal habitat use by river otters and Everglades mink in Florida. Journal of Wildlife Management 46: 375-381.

Jenkins, D., and G. O. Burrows. 1980. Ecology of otters in northern Scotland, III. The use of faeces as indicators of otter (*Lutra lutra*) density and distribution. Journal of Animal Ecology 49: 755-774.

Johnson, N. L., and S. Kotz. 1969. Discrete distributions. John Wiley and Sons. New York. 328 pp.

Knaus, R. M., N. Kinler, and R. G. Linscombe. 1983. Estimating river otter population: the feasibility of ⁶⁵Zn to label feces. Wildlife Society Bulletin 11: 375-377.

Linhardt, S. B., and F. F. Knowlton. 1975. Determining the relative abundance of coyotes by scent station lines. Wildlife Society Bulletin 3: 119-124.

MacDonald, S. M., and C. F. Mason. 1975. Otters, their habitat and conservation in northeast Greece. Biological Conservation 31: 191-210.

Melquist, W. E., and M. G. Hornocker. 1983. Ecology of river otters in west-central Idaho. Wildlife Monograph 83. 60 pp.

Paetz, M. J., and J. S. Nelson. 1970. The fishes of Alberta. Queen's Printer, Government of Alberta, Edmonton, Alberta. 282 pp.

Reid, D. G. 1984. Ecological interactions of river otters and beavers in a boreal ecosystem. M.Sc. thesis, University of Calgary, Calgary, Alberta. 199 pp.

Robson, M. S. 1982. Monitoring river otter populations: scent stations vs. sign indices. M.Sc. thesis, University of Florida, Gainesville, Florida. 40 pp.

Robson, M. S., and S. R. Humphrey. 1985. Inefficacy of scent-stations for monitoring river otter populations. Wildlife Society Bulletin 13: 558-561.

Rowe, J. S. 1972. The forest regions of Canada. Environment Canada. Canadian Forest Service Publication 1300F. 172 pp.

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., New York. 312 pp.

Snedecor, G. W., and W. G. Cochran. 1980. Statistical methods, Seventh edition. The Iowa State University Press, Ames, Iowa. 507 pp.

Strahler, A. N. 1969. Physical geography. John Wiley and Sons, Inc., New York. 733 pp.

Strong, W. L., and K. P. Leggat. 1981. Ecoregions of Alberta. Alberta Energy and Natural Resources. Technical Report T/4. Edmonton, Alberta. 64 pp.

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Notes

Effects of Nest-site Loss on Common Loons, *Gavia immer*

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Barricading of previously used nest bowls of Common Loons (*Gavia immer*) did not greatly affect nesting patterns. Nesting frequency (60%) was less than at unbarricaded sites, but nesting success (67%) was greater. New nest locations were 0-500 m from barricaded sites. Four of 12 new nests were within 5 m of the barricades. Twenty of 23 nests were within 5 m of old nest bowls in territories without barricaded nests. Water level seemed to affect locations of new nests.

Key Words: Common Loons, *Gavia immer*, nest-site availability, water level, barricades.

Results from voice-printing studies (Ed Miller, Governors State University, personal communication) and limited band recoveries (McIntyre 1974; Eberhardt 1984; Strong et al. 1987b) suggest that Common Loons (*Gavia immer*) return to the same breeding lakes and territories each year. Common Loons also show site affinity to nesting areas. Typically, nests are within 50 m of an old nest site and often are in a previously used nest bowl (McIntyre 1975; Titus and Van Druff 1981; Strong et al. 1987a). The importance of old nest bowls to nest-site selection and hatching success in subsequent years is unknown. We barricaded previously used nest bowls as part of a study of the factors that determine nest location for Common Loons.

Study Area and Methods

The study was conducted on five lakes in a small area of northern Maine (approximately 46°N, 69°W). Millinocket Lake, Hay Lake, Scraggly Lake, Millimagassett Lake, and Round Pond had few or no permanent homes and received only light recreational use. Depth, shoreline configuration, and fish populations were typical of lakes in this area (Strong 1985).

Nest bowls used by Common Loons in 1982 in six breeding territories on Hay and Millinocket Lakes were barricaded in 1983 and 1984. Nest bowls used in 1983 in eight additional territories on the other three lakes were barricaded in 1984. Nests built in 1983 in the six territories with barricades were not barricaded in 1984. In all, six nest bowls were barricaded for two consecutive years and eight for one year.

We erected barricades made of driftwood, rocks, and wire mesh soon after ice-off (early May). The barricades completely encircled the old nests and were approximately 25 cm high to prevent access by loons. There was little possibility of interrupting nest-site selection which did not occur until late May or early June in this area (Christenson 1981). After barricading, the shoreline area and islands in each territory were searched weekly for nests. Once found, nests were checked weekly to monitor their success.

We compared nesting frequency, hatching success, and nest location of loons in these territories to eight breeding pairs of loons on two nearby lakes during the same period (data presented in Strong et al. 1987a). We assumed that similar environmental conditions would prevail on all of the lakes and that territory and mate fidelity, which might affect nest location and success, was the same for both groups of lakes.

Results and Discussion

Nesting Frequency

Nesting frequency after barricading was 0.6 (12/20). Nests were initiated in eight of 14 territories the first year after barricading and in four of six the second year.

Nesting frequency for eight pairs of Common Loons on two nearby lakes was 1.0 (16/16) during the same period suggesting that barricading might have resulted in fewer nesting attempts. However, nesting frequency for Common Loons is typically 0.75-0.85 (Sutcliffe 1980; Strong et al. 1987a) indicating only a slightly lower frequency.

Nest Locations

New nest locations were 0-500 m from the barricaded sites. In one territory the loons nested inside the barricaded area after waves dislodged some of the barricade material. Three nests were within 1 m of the old nests adjacent to the barricades. Seven nests were 150-500 m from the barricaded sites and one nest was not found (however, chicks were seen later in the territory). Six of the seven nests ≥ 150 m from the barricaded sites were in different parts of the territories from the barricaded sites (i.e. different cove, island, bay). One was in the same backwater stream 400 m from the old nest.

Nest location did not seem to depend on the number of years the sites were barricaded. In two territories with the nest barricaded two consecutive years, the pairs nested both years. In one territory, the nest was next to the barricade the first year and 450 m away the next years. No eggs hatched the first year. In the other territory, the nest was 150 m from the barricade the first year and nest to the barricade the second. In this case eggs were hatched the first year following barricading. In two territories, nesting occurred only the second year after barricading; the nests were 400 and 450 m from the barricaded sites. For the territories in which nests were barricaded only one year, three nests were 150, 400, and 500 m from the barricaded sites, two were adjacent to the barricades, and one was not found.

Nest locations for the eight pairs on the other two lakes were closer to old sites. Thirteen of 23 original nests and re-nests were in old nest bowls used in a previous year. Seven of the ten new nests were within 5 m of old nest bowls. One nest was approximately 1000 m from the nearest known nest bowl; another was 200 m away, but in the same backwater stream. One nest built in 1983 and reused in 1984 was in a territory with no previous record of nesting although loons had occupied the territory since at least 1979.

Two of the nest bowls reused in 1983 had not been occupied since 1979 and 1980. One nest bowl was reoccupied after a one year vacancy. In each of these three cases, no nesting occurred in the territory while the old nest bowls were unused.

Nest bowls are reused frequently by Common Loons. McIntyre (1975) reported 30 percent reuse (14/47). Titus and Van Druff (1981) did not report reuse of nest bowls, but reported 46 percent (29/63) of nesting attempts within 5 m of the nest bowl used the previous year. Sutcliffe (1980) found only 4 of 55 nest bowls reused in his New Hampshire study. However, the new nests were often adjacent to or in the same general area (60-90 m) as old nest bowls.

Nesting Success

Nesting success (at least one egg hatching successfully) for the twenty nests the year prior to

barricading was 50 percent. Nesting success was 75 percent the first year after barricading and was 50 percent the second year after barricading. Nesting success for the eight territories on the two control lakes during the same three years was 100 percent ($n = 4$), 33 percent ($n = 12$), and 45 percent ($n = 11$).

Nesting success for Common Loons may be correlated to reuse of old sites (McIntyre 1975; Strong et al. 1987a). Nest reuse occurs more frequently when eggs are hatched successfully in the previous year. Nesting success was 100 percent the year prior to barricading for the four territories in which new nests were within 1 m of the barricades. Nesting success was 38 percent for the eight territories with new nests ≥ 150 m from the barricaded sites.

Nesting success at reused sites may be greater than at new sites (McIntyre 1975). However, Strong et al. (1987a) found no correlation for a large sample. Nesting success for nests within 1 m of barricaded sites was 75 percent. Five of eight (63 percent) nesting attempts ≥ 150 m from the barricaded sites were successful.

Water Levels

The barricade experiment was confounded somewhat by year to year water level fluctuations. Thirteen barricaded nests were under water during the entire nesting season (mid-May — early July). All seven new nests in these territories were ≥ 150 m from the barricades. Only seven barricaded nests were above water during nesting. Four of the five nests in these territories were within 1 m of the barricades. The one nest farther away was in a territory in which an ice-fishing shack was unintentionally pushed over the barricaded site.

Unfortunately, water levels did not fluctuate on the two nearby lakes used for comparison. All old nests were above water and visible to the loons in subsequent years.

Water levels are known to affect the timing of nesting of Common Loons (Barr 1986; Hildy Reiser, Northern Arizona University, personal communication) usually delaying nest initiation for several weeks. New nests may be constructed near old nest bowls even when water levels cover the old nest (Strong and Lutz 1986). However, Reiser (personal communication) found some pairs of loons nesting in completely different parts of their territories during years of high or low water in Voyageurs National Park in northern Minnesota.

Conclusion

Barricades around previously used nest bowls did not drastically alter the nesting frequency or nesting success of Common Loons. New nest locations varied greatly in their proximity to the barricaded sites. Loons seemed to prefer to nest near or in old nest

bowls. However, previous nesting success and water level seem to affect nest site location also. This study and one other report (Strong and Lutz 1986) suggest that the visibility of old nest bowls may be a stimulus for nest-site selection. However, initiation of nests in new locations when old nests are unavailable or when nesting fails (McIntyre 1975) indicates that Common Loons are flexible with respect to selecting nest sites.

Recent studies have reported the Common Loon's ability to accommodate human disturbance (Christenson 1981; Smith 1981; Titus and Van Druff 1981; Heimberger et al. 1983) and to adapt on the short-term to early stages of lake acidification (Parker 1985). The results of this study further demonstrate the ability of the Common Loon to adapt to moderate changes in the environment.

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Literature Cited

- Barr, J. F.** 1986. Population dynamics of the Common Loon (*Gavia immer*) associated with mercury-contaminated waters in northwestern Ontario. Canadian Wildlife Service Occasional Report Number 56.
- Christenson, B. L.** 1981. Reproductive ecology of and response to disturbance by Common Loons in Maine. M.Sc. thesis, Department of Wildlife, University of Maine, Orono.
- Eberhardt, R. T.** 1984. Recent recoveries of Common Loons banded in Minnesota. Loon 56: 202-203.
- Heimberger, M., D. Euler, and J. Barr** 1983. The impact of cottage development on Common Loon reproductive success in central Ontario. Wilson Bulletin 95: 431-439.
- McIntyre, J. W.** 1974. Territorial affinity of a Common Loon. Bird Banding 45: 178.
- McIntyre, J. W.** 1975. Biology and behavior of the Common Loon (*Gavia immer*) with reference to its adaptability in a man-altered environment. Ph.D. thesis, Department of Zoology, University of Minnesota, Minneapolis.
- Parker, K. E.** 1985. Foraging and reproduction of the Common Loon (*Gavia immer*) on acidified lakes in the Adirondack Park, New York. M.Sc. thesis, Department of Environmental and Forest Biology, State University of New York, Syracuse.
- Smith, E. L.** 1981. Effects of canoeing on Common Loon production and survival on the Kenai National Wildlife Refuge, Alaska. M.Sc. thesis, Department of Fishery and Wildlife Biology, Colorado State University, Ft. Collins.
- Strong, P. I. V.** 1985. Habitat selection by Common Loons. Ph.D. thesis, Department of Wildlife, University of Maine, Orono.
- Strong, P. I. V., and B. W. Lutz.** 1986. Strong affinity to an old nest and hatching of an abandoned egg by Common Loons. Passenger Pigeon 48: 74-75.
- Strong, P. I. V., J. A. Bissonette, and J. S. Fair.** 1987. Reuse of nesting and nursery areas by Common Loons. Journal of Wildlife Management 51: 123-127.
- Strong, P. I. V., S. A. LaValley, and R. C. Burke, II.** 1987. A colored plastic leg band for Common Loons. Journal of Field Ornithology 58: 218-221.
- Sutcliffe, S. A.** 1980. Aspects of the nesting ecology of Common Loons in New Hampshire. M.Sc. thesis, Institute of Natural and Environmental Resources, University of New Hampshire, Durham.
- Titus, J. R., and L. W. Van Druff.** 1981. Response of the Common Loon to recreational pressure in the Boundary Waters Canoe Area, northeastern Minnesota. Wildlife Monograph 79.

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The First Record of Grass Carp, *Ctenopharyngodon idella*, in Canadian Waters

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An exotic cyprinid, *Ctenopharyngodon idella* (758 mm total length) was captured in Canadian waters of Lake Erie in September 1985.

Key Words: *Ctenopharyngodon idella*, Grass Carp, Lake Erie, first Canadian record.

The freshwater fish fauna of Canada continues to increase as a result of the northward movement of North American species which occurred previously only in the United States. Those events do not normally cause any considerable concern. The northward movement of certain exotic species introduced in the U.S. is another matter. The discovery of *Ctenopharyngodon idella* (Valenciennes) could be the beginning of a situation comparable only to that resulting from the escape into public waters years ago of captive Common Carp, *Cyprinus carpio*.

On 27 September 1985 P.K. captured a fish unknown to him in a trap net set in Lake Erie approximately 1 km off the west shore of Point Pelee National Park at the level of Lake Pond (41°57'40"N, 80°32'30"W). It was a male of the cyprinid species *Ctenopharyngodon idella*. When fresh, the specimen was 700 mm FL (fork length), 758 mm TL (total length) and 5.3 kg in weight (Figure 1).

Guillory (1980) indicated that there have been many records of this species from the state of Michigan in streams flowing into western Lake Erie and Lake St. Clair. The only records indicated by him for the state of Ohio were not from a Lake Erie tributary, but from an Ohio River tributary (Olentangy R.?) More recent Lake Erie records from Ohio are from the mouth of the Toussaint River west of Port Clinton, Ottawa Co., Ohio, 16 March 1985, and Trane Creek, western Lake Erie near Bono, Ohio, 30 April 1986 (personal communication, Ohio Department of Natural Resources). The only other record contiguous to Canadian waters is one on the south shore of Lake Ontario, near Rochester, N.Y. It would appear probable that this species has moved eastward around the end of Lake Erie from Michigan rather than across the west end of the lake. This route has been suggested for other recent immigrants (Crossman and Simpson 1984).

These Michigan and Ohio records are unusual since Allen and Wattendorf (1987) indicated that both diploid and triploid Grass Carp were prohibited in those two states.

The Grass Carp is a large, cylindrical cyprinid with a small, broad, blunt head, subterminal mouth, unspecialized lips and no barbels. The anal fin is far back on the body. The distance from the anal fin origin to the caudal base goes three or more times into the distance from anal origin to the tip of the snout (Pflieger 1975). The origin of the short-based dorsal fin (7 or 8 rays) is directly over or slightly behind the origin of the pelvic fins. Scales in the lateral line (40-45) are large compared to those of native cyprinids, and scales on the back and sides are prominently marked with dark pigment. Number and arrangement of pharyngeal teeth is often cited in North American literature as 2,4-4,2. Berg (1965), however, gave a range of combinations including one tooth in the inner row and five in the outer row. The right pharyngeal arch of the Lake Erie specimen (Figure 2) had 1, 5 teeth. These teeth are large and long, and the crowns are strongly compressed with deep parallel grooves on the sides and grinding surfaces. *Ctenopharyngodon* means "comb-like throat teeth." *C. idella* is a large cyprinid, said to reach 1 m in length (Smith 1979) and 32 kg (Berg 1965) or 45 kg (Fedorenko and Fraser 1978) in weight.

We suggest that the only probable confusion in identification in Ontario would be with large individuals of *Semotilus corporalis*. General body shape is vaguely similar, scales are large and prominently pigmented (differently, however), and pharyngeal teeth can be the same in number and arrangement. The head of *S. corporalis* is larger in relation to body length, the anal fin is farther forward (2+ times rather than 3+ times for the ratio given above for *C. idella*), and the crowns of the teeth would not be



FIGURE 1. *Ctenopharyngodon idella* — 758 mm TL., male, Lake Erie, 1985. ROM 49248.

as compressed or grooved. Large *S. corporal* would probably have visible flap-like maxillary barbels. *S. corporal* does not presently occur in Lake Erie, so this confusion will not occur unless pioneers cross eastern Lake Ontario.

This species, sometimes referred to as the White Amur, was first introduced in Alabama and Arkansas from Taiwan and Malaysia and now exists in at least 40 U.S. states. Its native range is from the Amur River in Eastern U.S.S.R. south to the West River in

Southwest China and Thailand (Guillory 1980). It tolerates water temperatures of 0-35°C and oxygen concentrations as low as 0.0005 ppt (Guillory 1980). It is largely vegetarian, apparently consumes more than its body weight in food per day, and in Illinois, reaches 6.5 kg by its third summer (Smith 1979). Egg number was cited by Berg (1965) as 816 000 for an individual in the U.S.S.R. 76 cm in length and 7.4 kg in weight. This measure of reproductive potential is double that of the muskellunge, *Esox masquinongy*, one of the more fecund of local species, but lower than that of the carp, *Cyprinus carpio*. The testis of the specimen reported here was not highly developed.

The major apprehension, as stated by Pflieger (1975), is that *C. idella* may destroy fish and wildlife habitat by eliminating all vegetation. The Grass Carp was originally imported into the U.S. as a possible control of nuisance aquatic vegetation; potential damage to desirable vegetation represents its major detractor in Canada (see Fedorenko and Fraser 1978). Apparently (Anonymous 1987) Grass Carp "located in ponds have been known to eat the roots out from under plants growing along the shoreline and even drag vegetation down into the water once they have exhausted the supply of submerged and emergent water plants." It also consumes animal matter and may be a scavenger (Smith 1979) or predator on young fishes (Fedorenko and Fraser 1978). Smith and Shireman (1983) summarized much of the biology of this species.



FIGURE 2. *Ctenopharyngodon idella*, showing the right pharyngeal arch with characteristic deep parallel grooves in the four teeth in the principal row.

The risk of an established population in Canada is somewhat lessened by the fact that it apparently grows well only in warm water, spawns (only?) in running water at 27–29°C (Wheeler 1975), and is not known to be established at most of the sites where it has been introduced (Guillory 1980). However, the northern limit of native distribution (approximately 50°N) corresponds to a line through Ontario at the level of Lake Nipigon.

Grass Carp supplied now from Stuttgart, Arkansas, for introduction in U.S. states are certified by the U.S. Fish and Wildlife Service to be triploid (Anonymous 1985) and therefore sterile. The nature of the testis of the Lake Erie specimen suggests that animal may not have been sterile.

Acknowledgments

Photos by Bill Robertson, ROM.

Literature Cited

- Allen, S. K., Jr., and R. J. Wattendorf. 1987. Triploid grass carp: status and management implications. *Fisheries* 12(4): 20–24.
- Anonymous. 1985. Fish and Wildlife Service will certify grass carp. *Fisheries* 10(6): 54.
- Anonymous. 1987. Grass carp catch concerns Minnesota-Wisconsin DNR biologists. The Mainstream, Newsletter of the North Central Division, American Fisheries Society 5(1): 11.
- Berg, L. S. 1965. *English Editor*. Freshwater fishes of the U.S.S.R. and adjacent countries. Academy of Sciences of the U.S.S.R., Zoological Institute. Guide to the Fauna of the U.S.S.R. No. 30. Israel Program for Scientific Translations, Jerusalem. 3 volumes 510 pp.
- Crossman, E. J., and R. C. Simpson. 1984. Warmouth, *Lepomis gulosus*, a freshwater fish new to Canada. *Canadian Field-Naturalist* 98(4): 496–498.
- Fedorenko, A. Y., and F. J. Fraser. 1978. Review of grass carp biology. Ottawa, Fisheries and Oceans Technical report number 786. 15 pp.
- Guillory, V. 1980. *Ctenopharyngodon idella*. P. 151 in D. S. Lee, C. R. Gilbert, C. J. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina Biological Survey, Publication Number 1980-12. 854 pp.
- Pflieger, W. L. 1975. The fishes of Missouri. Missouri Department of Conservation. 343 pp.
- Smith, P. W. 1979. The fishes of Illinois. University of Illinois Press. 314 pp.
- Smith, C. R., and J. V. Shireman. 1983. Synopsis of biological data on the grass carp, *Ctenopharyngodon idella*. FAO Fisheries Synopsis Number 135. 86 pp.
- Wheeler, A. 1975. *Fishes of the World*. Macmillan Publishing Co., New York, New York. 366 pp.

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Feeding-site Use by Red Squirrels, *Tamiasciurus hudsonicus*, in a Marginal Habitat in Pennsylvania

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Proximal features associated with feeding sites used by Red Squirrels (*Tamiasciurus hudsonicus*) in aspen (*Populus* spp.) habitat were examined in central Pennsylvania. Primary feeding sites were characterized by higher densities of understory trees and lower densities of shrubby *Vaccinium* spp. than secondary sites. In addition, primary sites tended to be near underground burrow entrances, overstory Pitch Pines (*Pinus rigida*) containing cones, and other primary sites compared to secondary sites. Feeding-site use by Red Squirrels in this marginal habitat may help minimize predation risks and energetic costs related to foraging.

Key Words: Red Squirrel, *Tamiasciurus hudsonicus*, feeding sites, habitat, Pennsylvania.

An understanding of habitat use by populations occupying marginal habitats provides insight into basic requirements of a species across its geographical range. Boreal coniferous forests are optimal habitat for Red Squirrels (*Tamiasciurus hudsonicus*), providing stable, economically defensible sources of

conifer seeds as food and dense stands of interlocking conifers for placement of tree nests (Layne 1954; Smith 1968; Rusch and Reeder 1978; Yahner 1980; Vahle and Patton 1983). In aspen (*Populus* spp.) stands at the Barrens Grouse Habitat Management Study Area (BGMA) in central Pennsylvania,

resident populations of Red Squirrels are sparse ($< 10/100$ ha, unpublished data). Furthermore, these stands contain few conifers and few mast-producing and cavity-producing deciduous trees (Yahner and Grimm 1984), indicating that aspen cover type represents a marginal habitat for Red Squirrels (after Rusch et al. 1982). Feeding sites of Red Squirrels were commonly encountered as part of an ongoing study of sciurids at the BGMA. Feeding-site use may be based on habitat features that reduce predation risks during feeding and/or energetic costs associated with food acquisition. The objective of this study was to characterize habitat features associated with feeding sites used by Red Squirrels in a marginal habitat.

The study was conducted in a 18-ha portion of the BGMA, State Game Lands 176, Centre Co., Pennsylvania ($40^{\circ}47'N$, $78^{\circ}58'W$), from March to September 1984. The study area consists of a linear strip (1800×100 m) of uncut, 60-year-old aspen forest. Adjacent to the boundaries of the study area are alternating, 1-ha (100×100 m) aspen plots of two age classes that were clearcut in winters 1976-77 and 1980-81. Overstory trees (≥ 1.5 m tall, ≥ 7.5 cm dbh (diameter at breast height)) in the study area primarily include Bigtooth Aspen (*Populus grandidentata*), Quaking Aspen (*P. tremuloides*), and scattered Pitch Pine (*Pinus rigida*). Major understory trees (≥ 1.5 m tall, < 7.5 cm dbh) and shrubs (< 1.5 m tall, < 2.5 cm dbh) are aspen, Scrub Oak (*Quercus ilicifolia*), Dwarf Chinkapin Oak (*Q. prinoides*), and blueberry (*Vaccinium* spp.) [see Yahner and Grimm 1984, for details on vegetation].

Approximately 490 man-hours were spent systematically searching the study area for caches and feeding sites of Red Squirrels. No primary (middens) or secondary caches (Smith 1968; Vahle and Patton 1983) were found. However, 512 feeding sites were noted; these sites contained small piles of cone fragments but no intact, cached cones. The number of cone axes (cores) per site ranged from 1 to 103. Forty-five sites contained ≥ 30 axes; these were termed primary feeding sites. Of the remaining sites, 335 had ≥ 10 axes; 45 of these were selected randomly and were classified arbitrarily as secondary feeding sites.

Twenty-nine habitat features were quantified at each primary and secondary feeding site: density (no./ha) and basal area (m^2 /ha) of overstory trees (*Pinus rigida*, *Populus tremuloides*, *Quercus alba*, *Prunus serotina*, snags and all species combined) within a 5-m radius circle centered on the site; density (no./ha) of understory trees (*Populus tremuloides*, *Q. ilicifolia*, *Q. prinoides*, *Prunus serotina*, and all species combined) within two perpendicular, 1×10 m transects centered on the site; density (no./ m^2) of shrubs (*Q. ilicifolia*, *Q. prinoides*, *Vaccinium* spp., and

all species combined) within a 1-m radius circle centered on the site; distance (≥ 10 m or < 10 m) of a site from a forest-clearcut interface; presence or absence of another primary feeding site, another secondary feeding site, a tree nest, a tree cavity, or a burrow entrance (see Yahner 1980) within 10 m of the site; presence or absence of a substratum (overstory tree, fallen log > 7.5 cm in diameter, or stump > 7.5 cm in diameter) within 1 m of the site; and presence or absence of cones on the pine tree nearest to the site.

Habitat features of primary and secondary feeding sites were compared using Mann-Whitney tests or 2×2 G-tests of independence (Sokal and Rohlf 1981). Stepwise logistic regression (BMDPLR; Dixon 1981) was used to predict use of primary versus secondary feeding sites based on habitat features in which a value of $P \leq 0.10$ was obtained from Mann-Whitney tests or tests of independence. The logistic classification model used was $E(s/n) = \exp(U) / 1 + \exp(U)$, where U is the linear function of one or more independent variables, s is the sum of the binary (0,1) dependent variables, and n is the total sample size (Dixon 1981).

Six of the 29 habitat features varied between primary and secondary feeding sites (Table 1). Densities of both understory *P. serotina* and all species of understory trees combined were greater at primary sites than at secondary sites. These two habitat features were correlated ($r = 0.34$, $df = 88$, $P < 0.01$). Dense understory trees around primary sites conceivably afforded protection from surprise attacks by aerial predators, such as *Accipiter* spp. at the BGMA (Yahner 1984). Similarly, high densities of small trees and shrubs around drumming sites likely reduce predation risks for male Ruffed Grouse, *Bonasa umbellus* (Stoll et al. 1979). In contrast, density of *Vaccinium* spp. tended to be greater at secondary sites compared to primary sites. Dense patches of *Vaccinium* spp. at secondary sites produced a nearly impenetrable mat of stems at ground level. Sites with this habitat feature were probably less attractive for feeding because they may have impeded a squirrel from either perching at ground level or escaping potential predators while feeding.

Primary feeding sites were more often associated with burrow entrances (NEARBUR), overstory pines with cones (NEARCONE), and other primary sites (NEARPRI) than secondary sites (Table 1). These three habitat features also predicted use of primary versus secondary feeding sites by Red Squirrels: $U = 0.65 + 1.06$ (NEARBUR) - 0.69 (NEARCONE) + 0.58 (NEARPRI) (improvement chi-square = 5.45, $df = 1$, $P = 0.02$). Neither primary nor

TABLE 1. Comparison of significant ($P < 0.10$) habitat features measured at primary and secondary feeding sites used by Red Squirrels in a marginal habitat in central Pennsylvania. Values for densities are means \pm SD and were tested with Mann-Whitney tests; values for proportions are percentages and were tested with G-tests of independence. The latter five features were used in the stepwise logistic regression analysis (see text).

Feature	Feeding site		
	Primary	Secondary	P
Density (no./m ²) of understory trees:			
<i>Prunus serotina</i>	0.40 \pm 0.32	0.24 \pm 0.29	< 0.01
All species combined	1.45 \pm 0.61	1.11 \pm 0.46	< 0.01
Density (no./m ²) of shrubs:			
<i>Vaccinium</i> spp.	14.81 \pm 12.58	21.12 \pm 19.28	< 0.10
Proportion of sites near:			
Burrow entrance (NEARBUR)	24.4	6.7	< 0.05
Overstory pine with cones (NEARCONE)	80.0	62.2	< 0.10
Another primary feeding site (NEARPRI)	40.0	6.7	< 0.001

secondary sites were located near tree nests or cavities (see Vahle and Patton 1983). However, nearby burrow systems could serve as home sites and refugia for squirrels using primary feeding sites at the BGMA; most of these systems had been abandoned by Woodchucks (*Marmota monax*). Red Squirrels are known to use burrow systems in other types of habitats that are devoid of either conifers with interlocking crowns for tree nests or deciduous trees with cavities. For example, in farmstead shelterbelts of the intensively-farmed regions of the Midwest, Red Squirrels may use abandoned burrow systems of Thirteen-lined Ground Squirrels, *Spermophilus tridecemlineatus* (Yahner 1980). The presence of a primary site typically near an overstory pine with cones, which provided a temporary but readily-available food resource, is not surprising in this marginal habitat (see Rusch and Reeder 1978). However, Red Squirrels at the BGMA perhaps used alternate food items, such as fungi and meristematic buds and seeds of deciduous trees (Reichard 1976; Fisch and Dimock 1978; Rusch and Reeder 1978; Weigl and Hanson 1980). Although abundant in summer at the BGMA, fruit of *Vaccinium* spp. was probably not consumed by Red Squirrels (Rusch and Reeder 1978; but see Smith 1968).

The locations of feeding sites used by Red Squirrels in the marginal habitat in this study were associated with proximal habitat features that minimized predation risks and energetic costs associated with food acquisition. These features may also be expected to be important to *T. hudsonicus* in more typical habitats when selecting microenvironments for feeding. However, in the marginal habitat at BGMA, feeding-site use is related to features in the vicinity, such as burrow systems or isolated overstory pines

with cones. These features may be less important to Red Squirrel populations in more optimal habitats.

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Literature Cited

- Dixon, W. J., *Editor*. 1981. BMDP statistical software. University of California Press, Berkeley, California. 756 pp.
- Fisch, G. G., and E. J. Dimock, II. 1978. Shoot clipping by Douglas Squirrels in regenerating Douglas fir. *Journal of Wildlife Management* 42: 415-418.
- Layne, J. N. 1954. The biology of the Red Squirrel, *Tamiasciurus hudsonicus loquax* (Bangs), in central New York. *Ecological Monographs* 24: 227-267.
- Reichard, T. A. 1976. Spring food habits and feeding behavior of Fox Squirrels and Red Squirrels. *American Midland Naturalist* 96: 443-450.
- Rusch, D. A., and W. G. Reeder. 1978. Population ecology of Alberta Red Squirrels. *Ecology* 59: 400-420.
- Rusch, D. A., W. G. Reeder, and D. H. Rusch. 1982. Eye lens, testes, and body weight trends in Alberta Red Squirrels. *Journal of Wildlife Management* 46: 1010-1017.
- Smith, C. C. 1968. The adaptive nature of social organization in the genus of tree squirrels *Tamiasciurus*. *Ecological Monographs* 38: 31-63.
- Sokal, R. R., and F. J. Rohlf. 1981. *Biometry*. W. H. Freeman, San Francisco, California. 859 pp.
- Stoll, R. J., Jr., M. W. McClain, R. L. Boston, and G. P. Honchul. 1979. Ruffed Grouse drumming site character-

- istics in Ohio. *Journal of Wildlife Management* 43: 324-333.
- Vahle, J. R., and D. R. Patton. 1983. Red Squirrel cover requirements in Arizona mixed conifer forests. *Journal of Forestry* 81: 14-15, 22.
- Weigl, P. D., and E. V. Hanson. 1980. Observational learning and the feeding behavior of the Red Squirrel *Tamiasciurus hudsonicus*: the ontogeny of optimization. *Ecology* 61: 213-218.
- Yahner, R. H. 1980. Burrow system use by Red Squirrels. *American Midland Naturalist* 103: 409-411.
- Yahner, R. H. 1984. Winter (1983) birds of the Barrens Grouse Management Area. *American Birds* 38: 39.
- Yahner, R. H., and J. W. Grimm. 1984. Effects of edge, age, and cover type on wildlife microhabitats in even-aged forest stands in central Pennsylvania. *Proceedings of the Pennsylvania Academy of Science* 58: 60-66.

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Aleutian Tern, *Sterna aleutica*, A New Bird for Canada

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Hearne, Margo E., and John M. Cooper. 1987. Aleutian Tern, *Sterna aleutica*, a new bird for Canada. *Canadian Field-Naturalist* 101 (4): 589-590.

The first Canadian specimen record of the Aleutian Tern (*Sterna aleutica*) was obtained at Masset, British Columbia, on 10 May 1985.

Key Words: Aleutian Tern, *Sterna aleutica*, first Canadian record.

The Aleutian Tern, *Sterna aleutica*, is a rare and poorly known species that inhabits the northwest Pacific, Bering Sea, and Gulf of Alaska. Historical and current breeding colonies have been documented in Alaska at Norton Sound, Goodnews Bay, Kodiak Island, and near Yakutat and in the USSR on Sakhalin Island and the Kamchatka Peninsula (Gabrielson and Lincoln 1959; Flint et al. 1984). In recent years several active breeding colonies have been documented in the Gulf of Alaska near Cordova and as far south as Yakutat (approximately 59° 30'N, 139° 50'W) (Patten 1981). The species' non-breeding distribution is poorly known. Its winter range is described as the northwestern Pacific south to Hokkaido (Peters 1934). In North America the Aleutian Tern has not previously been documented outside Alaska.

On 10 May 1985 M.E.H. was given an Aleutian Tern (Figure 1) by a local resident who had found the bird dead, behind a drift log, on the northeast beach of Masset Inlet at Masset, British Columbia (54° 01'N, 172° 10'W). This specimen (British Columbia Provincial Museum number 18367) represents the first documented record of the Aleutian Tern in Canada and the southernmost record in the eastern Pacific. The nearest breeding colony is near Yakutat, Alaska, 770 km northwest of Masset. Standard measurements were exposed culmen — 34.7 mm, tarsus — 19 mm, wing chord — 273 mm, weight —



FIGURE 1. Photograph of the Aleutian Tern skin.

123 g, ovary 12 × 9 mm, and largest follicle — 2 mm. The bird seemed to be in good condition and had medium amounts of body fat. Two holes, 5 mm in diameter, were present on the neck.

In addition to the above specimen, M.E.H. and two other observers, the Rev. P. Hamel and C. Bellis, saw an Aleutian Tern near Masset on 30 May 1983. That tern was observed from a small boat 1 km offshore of Masset at 0730 h. It was flying north towards the mouth of Masset Inlet, close to the northeast shore and was observed for approximately 30 seconds. However, no evidence exists, except field notes, to

substantiate this earlier sighting of what was then a species unrecorded in Canada.

Literature Cited

- Flint, V. E., R. L. Boehme, Y. V. Kostin, and A. A. Kuznetsov. 1984. A field guide to birds of the U.S.S.R. Princeton University Press.
- Gabrielson, I. N., and F. C. Lincoln. 1959. Birds of Alaska. Telegraph Press.

Patten, S. M., Jr. 1981. Seasonal use of coastal habitat from Yakutat Bay to Cape Fairweather by migratory seabirds, shorebirds, and waterfowl. U.S. Department of Commerce, Alaska.

Peters, J. L. 1934. Check-list of birds of the World. Harvard University Press.

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Walrus, *Odobenus rosmarus*, and Whale Interactions: an Eyewitness Account

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Mazzone, W. Seven. 1987. Walrus, *Odobenus rosmarus*, and whale interactions: an eyewitness account. Canadian Field-Naturalist 101 (4): 590-591.

An attack by Killer Whales, (*Orcinus orca*) on a group of Walruses, (*Odobenus rosmarus*) at Cape Peirce, Alaska, is described. The Killer Whales surrounded, isolated, and attacked one Walrus. A Gray Whale (*Eschrichtius robustus*) encountered and killed a large adult male Walrus in the same area.

Key Words: Walrus, *Odobenus rosmarus*, Killer Whale, *Orcinus orca*, Gray Whale, *Eschrichtius robustus*, predation, Bering Sea, Cape Peirce.

Interactions between Walruses (*Odobenus rosmarus*), Killer Whales (*Orcinus orca*), and Gray Whales (*Eschrichtius robustus*) in the area of Cape Peirce, Alaska, were observed on two occasions between 1 June and 1 October 1985. The Cape Peirce hauling grounds, used during the summer by approximately 8500 Walruses, are located in western Alaska at the northwest tip of Bristol Bay, 58°35'N, 161°45'W. During June 1985 several sightings of Gray Whales moving north along the coast were recorded. In their spring migration Gray Whales move north along the coast from Baja California to their summer feeding grounds in the Bering and Chukchi seas (Rice and Wolman 1971). During migration whales travel relatively close to the shore following shallow coastal waters, whereas in the fall their southerly migration pattern is more direct, and they travel far off shore.

On 7 July 1985 a large adult Gray Whale moved into the feeding area of a group of approximately 70 Walruses. The whale moved parallel to the shoreline about 270 m from the beach. Its movement pattern indicated that it was feeding along the bottom, surfacing about every 130 to 180 m to blow. The encounter between the Walruses and the Gray Whale involved a sudden flurry of activity and the majority of the walruses moved toward the beach. The whale

did a complete flip and turned 180 degrees; its large flukes were completely visible and at times its body was arched out of the water. During the encounter the Gray Whale apparently struck and killed a large adult male Walrus with its fluke. The Walruses chased the Gray Whale about 800 m out into the bay, returning with much blowing and bellowing and much nasolateral greeting. The Gray Whale was last sighted moving north along the coast about 1 km north of the incident. The dead Walrus later washed up on the beach and a necropsy revealed massive contusions around the head and neck with extensive internal hemorrhaging. The incident lasted approximately 12 minutes and caused no disturbance to any of the animals on the beach, nor did it appear to bother any of the Walruses outside the immediate area. I believe the killing of the Walrus could have been accidental rather than intentional.

The second incident involved four Killer Whales and a group of three Walruses, and occurred 18 July 1985. The Killer Whales were about 400 m off shore moving in a northerly direction when they surrounded and attacked the Walruses that were moving towards the beach. The Killer Whales began circling the Walruses and then singled out one walrus and began diving under it and closing in on it in an ever-

tightening circle. This attack behavior is similar to accounts reported by Nikulin (1941) and Zenkovich (1938) cited in Fay (1982). One of the other two Walruses escaped; the third Walrus was not seen again.

The Killer Whales dove under the Walrus and threw it completely out of the water. The Killer Whales were very active and breached often, exposing their entire bodies in aerial displays. The Walrus attempted to keep its head above the water and faced the Killer Whales with its head back and tusks pointed out in a threatening gesture. The Walrus struck at the whales on several occasions, although there was no indication that a whale was hit. The entire confrontation lasted 18 minutes and ended suddenly when all participants disappeared below the surface. I believe that the Walrus was killed by the whales, although no carcass was found. However, a Walrus was observed 10 days after the incident with an 8 cm diameter slab of flesh and hide missing from its left side. Photos were taken of the wounded animal but the cause of the wound could not be determined.

During the Killer Whales' attack on the Walrus, activity of other animals in the vicinity was noted. Walruses on the beach became excited, struck at each other with their tusks and moved about on the beach. Walruses in the water either headed directly for the nearest beach and hauled out or gathered into small groups with their backs to the cliffs, facing toward the disturbance. Similar actions were recorded by Nikulin (1941) when Killer Whales were observed attacking young Walruses near an ice pack (Fay 1982). The Killer Whales did not bother other Walruses and completely ignored one Walrus that came within 100 m of them. At no time did any of the other Walruses move toward the confrontation. When the Killer Whales disappeared, the Walruses remaining in the water moved to the beaches. Little activity was observed in the bay for the remainder of the day, except for the occasional arrival of Walruses coming in from their feeding grounds to the west.

The Killer Whale is regarded as an important natural predator of Walruses, although the predation is mainly directed at younger animals, usually calves (Belopol'skii 1939; Nikulin 1941; Rice 1968; Zenkovich 1938). Carcasses believed to have been mauled by Killer Whales have been found throughout the Bering and Chukchi seas (Fay 1982; Murie 1936). The principal indications of a Killer Whale mauling are hide and flipper lacerations and extensive internal

injuries, consisting of broken bones and deep intramuscular hemorrhaging (Belopol'skii 1939; Fay 1982; Nikulin 1941).

From these two observations made at the Cape Peirce hauling grounds in 1985, it was apparent that predation on adult Walruses by Killer Whales occurs, but probably has minimal impact on the all-male herd. With a population fluctuation of between 500 and 8500 Walrus using the Cape Peirce haul-outs, only 26 Walrus carcasses washed up on the beach. Of these 26 carcasses, which were carefully examined, no mortalities could be attributed to Killer Whale attacks.

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Literature Cited

- Belopol'skii, L. O.** 1939. On the migrations and ecology of reproduction of the Pacific walrus (*Odobenus rosmarus divergens*). Zoologicheskii Zhurnal (Moscow) 18: 762-774. [In Russian with English summary]
- Fay, F. H.** 1982. Ecology and biology of the Pacific walrus, (*Odobenus rosmarus divergens*) (Illiger). North American Fauna Number 74. 279 pp.
- Murie, O. J.** 1936. Notes on the mammals of St. Lawrence Island, Alaska. Appendix 3. Pages 337-346 in O. W. Geist and F. G. Rainey, Archaeological excavations at Kukulik, St. Lawrence Island, Alaska. U.S. Government Printing Office, Miscellaneous Publications, University of Alaska, 2.
- Nikulin, P. G.** 1941. The Chukchi walrus. Izvestiia, TINRO (Vladivostok) 20: 21-59. [In Russian with English summary]
- Rice, D. W.** 1968. Stomach contents and feeding behavior of killer whales in the eastern North Pacific. Norsk Hvalfangst-Tidende 57: 35-38.
- Rice, D. W., and A. A. Wolman.** 1971. The life history and ecology of the gray whale (*Eschrichtius robustus*). American Society of Mammalogy, Special Publication Number 3. 142 pp.
- Zenkovich, B. A.** 1938. On the grampus or killer whale, (*Grampus orca*) Linn. Priroda (Moscow) 1938 (4): 109-112.

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Food Habits of Urban-Nesting Merlins, *Falco columbarius*, in Edmonton and Fort Saskatchewan, Alberta

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James, Paul C., and Alan R. Smith. 1987. Food habits of urban-nesting Merlins, *Falco columbarius*, in Edmonton and Fort Saskatchewan, Alberta. *Canadian Field-Naturalist* 101 (4): 592–594.

House Sparrows, *Passer domesticus*, constituted 77% of the identified diet at five nest sites of the Merlin, *Falco columbarius*, in the cities of Edmonton and Fort Saskatchewan between 1978 and 1980. Twenty-one other prey species were recorded, including an escaped Budgerigar, *Melopsittacus undulatus*, and two other locally rare species. The incidence of House Sparrows in the Edmonton diet increased significantly as the breeding season progressed, suggesting that Merlins preyed on newly-fledged House Sparrows; this was supported by the fact that the proportion of adult male sparrows in the sample declined at the same time. The results are compared with other studies of urban and rural diets in prairie Merlins.

Key Words: Merlin, *Falco columbarius*, prey, House Sparrow, *Passer domesticus*, urban, Alberta.

While it is generally accepted that the principal prey of Merlins, *Falco columbarius*, is small birds (for review see Sherrod 1978), few systematic food studies have been conducted in North America (Oliphant and McTaggart 1977; Hodson 1978; Becker 1985; Laing 1985). Of these, only one has considered the food habits of urban-breeding Merlins (Oliphant and McTaggart 1977), despite the fact that many cities and towns on the Canadian prairie-parklands now support populations. With this in mind, we report here on the food habits of Merlins breeding in the cities of Edmonton and Fort Saskatchewan (26 km NE of Edmonton), Alberta.

Methods

The data were collected at four nest sites visited in Edmonton in April (7 visits), May (13 visits), June (8 visits), and July (9 visits) from 1978 to 1980, and at one site in Fort Saskatchewan visited once in July 1978. During each visit, remains of prey were gathered for subsequent identification. For this purpose, only the heads or mandibles of remains collected were used. This avoided the problem of estimating the number of individuals eaten from a variety of body parts including feathers.

Results and Discussion

Birds were the only recorded prey type; of the total sample collected, only 1.5% could not be identified. House Sparrows, *Passer domesticus*, constituted 77% of the 194 prey items identified (Table 1). Two other species, the Bohemian Waxwing, *Bombycilla garrulus*, and White-winged Crossbill, *Loxia*

leucoptera, made up an additional 11% of the Edmonton Merlin diet. A total of 19 other species was recorded. The high proportion of House Sparrows in the diets is similar to that recorded (64%) in the only other study of urban Merlins conducted in Saskatoon, Saskatchewan (Oliphant and McTaggart 1977).

As in Saskatoon, the proportion of House Sparrows in the Edmonton diet increased significantly ($X^2 = 28.34$; d.f. = 3; $P < 0.005$) as the Merlin breeding season progressed from April (14/32 items; 44%) to May (33/42 items; 79%), June (37/41 items; 90%), and July (47/55 items; 86%). This occurred despite the spring influx of other breeding and migrant passerine species into the area, and suggests that the Merlins were preying upon the numerous newly-fledged House Sparrows. A recent survey of breeding House Sparrows in Saskatoon revealed that successfully-breeding pairs produced an average of 4.4 chicks, and may breed up to three times annually (P.C.J., unpublished observations).

Closer inspection of the Edmonton House Sparrow remains showed that the proportion of adult males in the sample decreased, although not significantly ($X^2 = 2.59$, d.f. = 3, N.S.), from 71% (10/14 sparrows) in April to 46% (15/33 sparrows) in May, 51% (18/35 sparrows) in June, and 43% (20/47 sparrows) in July. The higher proportion in April is probably due to the fact that incubating females are less available for capture. The first fledglings become available in late April. Because House Sparrows are multi-brooded, the decrease in the proportion of adult males taken is probably not due to adult females becoming more available, and supports the suggestion that fledgling

TABLE 1. Prey species of Merlins nesting in Edmonton and Fort Saskatchewan, Alberta, as determined by mandibular remains.*

Species	Edmonton		Fort Saskatchewan	
	Number	%	Number	%
House Sparrow, <i>Passer domesticus</i>	131	75.7	19	79.2
Bohemian Waxwing, <i>Bombycilla garrulus</i>	10	5.8	-	-
White-winged Crossbill, <i>Loxia leucoptera</i>	9	5.2	-	-
Chipping Sparrow, <i>Spizella passerina</i>	4	2.3	-	-
European Starling, <i>Sturnus vulgaris</i>	4	2.3	-	-
Savannah Sparrow, <i>Passerculus sandwichensis</i>	3	1.7	-	-
Pine Grosbeak, <i>Pinicola enucleator</i>	2	1.2	-	-
Say's Phoebe, <i>Sayornis saya</i>	1	0.6	-	-
Swainson's Thrush, <i>Catharus ustulatus</i>	1	0.6	-	-
American Robin, <i>Turdus migratorius</i>	1	0.6	1	4.2
Yellow-rumped Warbler, <i>Dendroica coronata</i>	1	0.6	-	-
Clay-colored Sparrow, <i>Spizella pallida</i>	1	0.6	-	-
Dark-eyed Junco, <i>Junco hyemalis</i>	1	0.6	-	-
Evening Grosbeak, <i>Hesperiphona vespertina</i>	1	0.6	-	-
Townsend's Solitaire, <i>Myadestes townsendi</i>	-	-	2	8.3
Rufous-sided Towhee, <i>Pipilo erythrophthalmus</i>	-	-	1	4.2
Red-winged Blackbird, <i>Agelaius phoeniceus</i>	-	-	1	4.2
Unidentified passerine	3	1.7	-	-
Total	173	100.1	24	100.1

*Non-mandibular remains were one Pine Siskin (*Carduelis pinus*), 1 Mountain Bluebird (*Sialia currucoides*), one Snow Bunting (*Plectrophenax nivalis*), one Killdeer (*Charadrius vociferus*), and one Budgerigar (*Melopsittacus undulatus*).

House Sparrows are important prey items at this time. Other studies have shown the importance of young, presumably more susceptible, avian prey to breeding Merlins (Newton et al. 1984) and other raptors (Newton and Marquiss 1982). All four European Starling, *Sturnus vulgaris*, prey recorded were immatures.

Four systematic studies have now reported on the diet of prairie Merlins, two urban (Table 1; Oliphant and McTaggart 1977) and two rural (Hodson 1978; Becker 1985). Comparison of the major prey species from these studies shows that Merlins utilize different prey in rural and urban environments (Table 2). For example, in contrast to rural birds, urban Merlins prey heavily on House Sparrows, and also take more waxwings. That rural Merlins do not prey on House Sparrows is interesting because the latter are locally abundant at farms and ranches. Perhaps the rural Merlins do not tolerate human presence as much.

The rural-nesting Merlins prey heavily on native grassland species, particularly the Horned Lark, *Eremophila alpestris*, Chestnut-collared Longspur, *Calcarius ornatus*, Vesper Sparrow, *Poocetes gramineus*, and Lark Bunting, *Calamospiza melanocorys*. However, the proportions of these prey species

varied between the two studies, probably reflecting differences in availability. It is also noteworthy that rural Merlins differ from city birds in that they utilize mammalian prey (Hodson 1978; Becker 1985).

Whatever the locale, however, breeding Merlins prey heavily on a few locally abundant passerine species. They may also select odd or novel prey (Mueller 1975). One of the House Sparrows taken was a partial albino, and the feathers of an escaped Budgerigar, *Melopsittacus undulatus*, were found (Table 1). The mandibles of two species, Townsend's Solitaire, *Myadestes townsendi*, and Rufous-sided Towhee, *Pipilo erythrophthalmus*, both considered to be rare in the area (Salt and Salt 1976), were also discovered.

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TABLE 2. Comparison (%) of the principal prey species of urban- and rural-nesting prairie Merlins.

Species	Urban		Rural	
	Oliphant and McTaggart (1977)	This study	Hodson (1978)	Becker (1985)
House Sparrow	64	76	0	< 1
Chestnut-collared Longspur	1	0	37	4
Vesper Sparrow	0	0	2	13
Lark Bunting	0	0	< 1	18
Horned Lark	6	0	50	27
Waxwing spp.	6	6	< 1	0
Other spp.	23	18	± 10	± 37

Literature Cited

Becker, D. M. 1985. Food habits of Richardson's Merlins in southeastern Montana. *Wilson Bulletin* 97: 226-230.

Hodson, K. 1978. Prey utilized by Merlins nesting in shortgrass prairies of southern Alberta. *Canadian Field-Naturalist* 92: 76-77.

Laing, K. 1985. Food habits and breeding biology of Merlins in Denali National Park, Alaska. *Raptor Research* 19: 42-51.

Mueller, H. C. 1975. Hawks select odd prey. *Science* 188: 953-954.

Newton, I., and M. Marquiss. 1982. Food, predation and breeding season in Sparrowhawks (*Accipiter nisus*). *Journal of Zoology* 197: 221-240.

Newton, I., E. R. Meek, and B. Little. 1984. Breeding season foods of Merlins *Falco columbarius* in Northumbria. *Bird Study* 31: 49-56.

Oliphant, L. W., and S. McTaggart. 1977. Prey utilized by urban Merlins. *Canadian Field-Naturalist* 91: 190-192.

Salt, W. R., and J. R. Salt. 1976. *The birds of Alberta*. Third edition. Hurtig Publishers, Edmonton, Alberta.

Sherrod, S. K. 1978. Diets of North American Falconiformes. *Raptor Research* 12: 49-121.

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Habitat Associations of Fleas, Siphonaptera, Parasitizing the Short-tailed Shrew, *Blarina brevicauda*

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Berseth, Wes C., and Paul Zubac. 1987. Habitat associations of fleas, Siphonaptera, parasitizing the Short-tailed Shrew, *Blarina brevicauda*. *Canadian Field-Naturalist* 101 (4): 594-596.

Short-tailed Shrews (*Blarina brevicauda*) were parasitized by different flea species in different habitats; i.e., *Doratomyss blarinae* and *Nearctopsylla genalis* in mixed woods, and *Ctenophthalmus pseudagyrtis* in old-field habitat.

Key Words: *Blarina brevicauda*, flea fauna, *Doratomyss blarinae*, *Nearctopsylla genalis*, *Ctenophthalmus pseudagyrtis*, habitat association.

It has been known for some time that flea species can be restricted to certain habitats in addition to being restricted to their hosts (Jameson 1947); however, few examples have been documented (eg. Jameson and Brennan 1957; Gabbutt 1961; Stark and Miles 1962; Layne 1963; Stark and Kinney 1969; Benton 1972). In this work we report the different flea assemblages parasitizing the Short-tailed Shrew,

Blarina brevicauda, in old-field and mixed-forest habitats.

Fleas were collected by brushing the bodies of Short-tailed Shrews that were captured in old-field habitat during July to November, 1983 and 1984, and in mixed-forest habitat during July to October, 1984. The old field was located in Newmarket, Ontario (44°03'N; 79°27'W), and the vegetation was

dominated by grasses (*Poa pratensis*, *Agropyron repens* and *Agrostis gigantea*) and sedges (*Carex* spp.). Various forbs such as Canada Thistle (*Cirsium arvense*), mints (*Mentha* spp.) Strawberry (*Fragaria virginiana*), Cow Vetch (*Vicia cracca*), goldenrods (*Solidago* spp.), and asters (*Aster* spp.) were present in lesser abundance. Other mammalian species regularly inhabiting this site were the Masked Shrew (*Sorex cinereus*), Star-nosed Mole (*Condylura cristata*), Woodchuck (*Marmota monax*) and Meadow Vole (*Microtus pennsylvanicus*).

The mixed forest was located near Elmvale, Ontario (44°35'N; 79°52'W), 65 km north of the Newmarket old-field site. The dominant tree vegetation was Eastern White Cedar (*Thuja occidentalis*), Eastern Hemlock (*Tsuga canadensis*), White Birch (*Betula papyrifera*), Yellow Birch (*B. lutea*), Red Maple (*Acer rubrum*), Sugar Maple (*A. saccharum*) and Beech (*Fagus grandifolia*). The mammalian species known to inhabit this site were Smokey Shrew (*Sorex fumeus*), Striped Chipmunk (*Tamias striatus*), Red Squirrel (*Tamiasciurus hudsonicus*), Southern Flying Squirrel (*Glaucomys volans*), Woodland Deer Mouse (*Peromyscus leucopus*), Meadow Jumping Mouse (*Zapus hudsonius*), and Woodland Jumping Mouse (*Napeozapus insignis*).

Short-tailed Shrews were captured regularly in both habitats, but this was not the case for individual flea species (Table 1). *Doratomylla blarinae* and *Nearctopsylla genalis* were the most abundant fleas in the mixed forest, with only a single *D. blarinae* and no

N. genalis collected in the old field. *Ctenophthalmus pseudagyrtis* was the most abundant flea in the old field and was scarce in the mixed woods. *Epitedia wenmanni* was collected infrequently and did not show a consistent preference for either habitat.

The abundance of the individual flea species was seen to be related to the time of the year as well as to habitat. Both *C. pseudagyrtis* and *D. blarinae* were collected during all months of the study, whereas *N. genalis* and *E. wenmanni* were not collected until late September and early October, respectively, except for a single *E. wenmanni* collected during August 1983.

The habitat in which the host lives has been found to influence the flea fauna of various mammalian species, including microtines (Jameson 1947; Benton 1972; Gabbutt 1961; Stark and Miles 1962), and *Peromyscus* spp. (Jameson and Brennan 1957; Layne 1963; Stark and Kinney 1969). Also, the time of year has been found to influence the flea fauna of numerous mammalian hosts, e.g. *Spermophilus beecheyi* (Rychmann et al. 1954), *Peromyscus leucopus* (Jackson and Defoliart 1976), and *Glaucomys volans* (Day and Benton 1980). Jameson (1950) found the flea fauna parasitizing *B. brevicauda* to vary with the seasons, but gave no indication of the importance of habitat.

In the present study both the season and the habitat of the host were important. Jameson (1950) found *D. blarinae* to occur on *B. brevicauda* during the warm months whereas *N. genalis* was collected only during the winter months, suggesting that a distinct temporal segregation of these two species would have been

TABLE 1. Numbers of the common flea species collected from *Blarina brevicauda* in two habitats.

Habitat (Year)	Month	Number of Shrews	Flea Species			
			<i>Ctenophthalmus pseudagyrtis</i>	<i>Doratomylla blarinae</i>	<i>Nearctopsylla genalis</i>	<i>Epitedia wenmanni</i>
Old field (1983)	July	4	2			
	August	7	4			1
	September	18	25			
	October	12	12			1
	November	15	30			3
Old field (1984)	July	4	9	1		
	August	13	9			
	September	29	17			
	October	26	15			11
	November	13	23			2
Forest (1984)	July	5		6		
	August	6		10		
	September	18	2	8	5	
	October	15	2	9	23	1

found in the mixed forest if sampling had been extended over the entire year. Although it is possible that a temporal segregation between *C. pseudagyrtes* and *E. wenmanni* may also have occurred, this cannot be concluded from our data. Jameson (1947) collected *E. wenmanni* very infrequently from *B. brevicauda* and did not find a seasonal difference in abundance of *C. pseudagyrtes*, so it may be that *C. pseudagyrtes* is essentially the sole flea species parasitizing *B. brevicauda* in grassland habitat.

Regardless of the time of year or habitat, the flea fauna parasitizing *B. brevicauda* was most often dominated by one of three species. It would be useful to know whether a similar pattern of habitat and seasonal segregation exists for fleas parasitizing other mammalian hosts that occupy diverse habitats as does *B. brevicauda*.

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Literature Cited

- Benton, A. H. 1972. Fleas and the second-order environment. *Journal of Medical Entomology* 9: 602.
- Day, J. F., and A. H. Benton. 1980. Population dynamics and coevolution of adult siphonapteran parasites of the southern flying squirrel (*Glaucomys volans volans*). *American Midland Naturalist* 103: 333-338.
- Gabbutt, P. D. 1961. The distribution of some small mammals and their associated fleas from central Labrador. *Ecology* 42: 518-525.
- Jackson, J. O., and G. H. Defoliart. 1976. Relationships of the white footed mouse, *Peromyscus leucopus*, and its associated fleas (Siphonaptera) in southwestern Wisconsin. *Journal of Medical Entomology* 13: 351-356.
- Jameson, E. W., Jr. 1947. Natural history of the prairie vole (Mammalian genus *Microtus*). University of Kansas Publications, Museum of Natural History 1: 125-151.
- Jameson, E. W., Jr. 1950. The external parasites of the short-tailed shrew, *Blarina brevicauda* (Say). *Journal of Mammalogy* 31: 139-145.
- Jameson, E. W., Jr., and J. M. Brennan. 1957. An environmental analysis of some ectoparasites of small forest mammals in the Sierra Nevada, California. *Ecological Monographs* 27: 45-54.
- Layne, J. N. 1963. A study of the parasites of the Florida mouse, *Peromyscus floridanus*, in relation to host and environmental factors. *Tulane Studies in Zoology* 11: 1-27.
- Ryckmann, R. E., C. C. Lindt, C. T. Ames, and R. D. Lee. 1954. Seasonal incidence of fleas on the California ground squirrel in Orange County, California. *Journal of Economical Entomology* 47: 1070-1074.
- Stark, H. E., and V. I. Miles. 1962. Ecological studies of wild rodent plague in the San Francisco Bay area of California. VI. The relative abundance of certain flea species and their host relationships on coexisting wild and domestic rodents. *American Journal of Tropical Medicine and Hygiene* 11: 525-534.
- Stark, H. E., and A. R. Kinney. 1969. Abundance of rodents and fleas as related to plague in Lava Beds National Monument, California. *Journal of Medical Entomology* 6: 287-294.

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Beaver, *Castor canadensis*, Colony Density in the Bearville Study Area, Northcentral Minnesota

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Fuller, Todd K., and Judy A. Markl 1987. Beaver, *Castor canadensis*, colony density in the Bearville study area, north-central Minnesota. *Canadian Field-Naturalist* 101 (4): 597-598.

Densities of active Beaver (*Castor canadensis*) colonies, determined from aerial searches of the same 36 2.6-km² quadrats each year in the 839-km² Bearville Study Area in north-central Minnesota during 1981-1985, increased from 0.58/km² to 0.86/km² (\bar{x} = 0.72/km²).

Key Words: Beaver, *Castor canadensis*, Minnesota, population.

Beavers, *Castor canadensis*, are an important non-winter food of Wolves, *Canis lupus*, in some areas of North America (Pimlott et al. 1969; Frenzel 1974; Voight et al. 1976; Theberge et al. 1978; Fritts and Mech 1981), and knowledge of Beaver abundance may eventually help to interpret differences in Wolf food habits between areas. In northern Minnesota, Beaver numbers are indexed by annual Minnesota Department of Natural Resources (MDNR) aerial counts of colonies along specified watercourses (Karns 1975). However, such counts are not comparable between areas because overall densities of streams and lakes are not known.

Numbers of individual Beavers per colony may change without changes in numbers of colonies (Swenson et al. 1983), but when numbers of colonies change, changes in mean family size may be positively correlated (Bergerud and Miller 1977). And though it is interesting to know mean family size per colony, it varies only about three fold across most of North America (3-9 per family) (Gunson 1970; Swenson et al. 1983; Hill 1982), whereas mean colony density may vary 10- to 100-fold between areas (Larson and Gunson 1983; Peterson et al. 1984). Because 1) the determination of mean colony size is both time-consuming and labor-intensive, and 2) the relative potential variation in colony size versus that for colony density across North America is extremely small, we believe counts of Beaver colonies provide useful indices to relative abundance. During October 1981-1985, we conducted aerial quadrat surveys to determine the density of Beaver colonies in a portion of north-central Minnesota where we were also studying Wolves.

Study Area

Beaver colony densities were estimated for the 839-km² Bearville Study Area (BSA) in northeastern

Itasca County, Minnesota (93° 15'N, 47° 45'W). Topography throughout the area is gently to strongly rolling and varies from 400 to 470 m above sea level. A few large (> 600 ha) lakes in the north and east and numerous smaller lakes in the southwest cover about 6% of the study area. Amount of lakeshore averages about 0.6 km/km², while density of permanent and intermittent streams averages about 0.3 km/km². Vegetation is mostly boreal coniferous-hardwood forest (Maycock and Curtis 1960; Mooty 1979; Fuller and Heisey 1986). During winters 1980-81 to 1984-85, January-March snow thickness averaged 26 cm. Snow cover is usually present from late November or early December through early to late April; ice usually appears on lakes and ponds in early November and disappears in early to late April. No reliable harvest data are available for the study area.

Methods

Numbers of Beaver colonies in the BSA were counted from aircraft in October each year on the same 36 2.6-km² quadrats. Initially, 4 quadrats were randomly selected in each of 9 townships (93 km² each; 11% coverage) to provide a well-distributed, unbiased sample. Quadrats were outlined on U.S. Geological Survey topographic or orthophoto maps (1:24,000). Surveys were flown in a Cessna 172 at 100-130 m above ground level and at 110-130 km/hr with 1 observer and the pilot. The search pattern consisted of flying clockwise in slightly overlapping, ever-decreasing concentric circles to cover the entire quadrat. Average search time for the 5 years ranged from 1.6 to 2.3 minutes/km². All beaver lodges and food caches were marked on maps and numbers of colonies were recorded. Colonies were identified by the presence of a food cache, or if no food cache was apparently present, by the presence of an active lodge (fresh cuttings at or on lodge) not adjacent to another colony (Hay 1958).

Results and Discussion

Mean density (number/km²) of active Beaver colonies in the study area during the five years was 0.72 (0.58 in 1981, 0.73 in 1982, 0.65 in 1983, 0.79 in 1984, and 0.86 in 1985), and increased ($r = 0.878$, 3 df, $P = 0.05$) at an average annual rate of 9 percent. These densities were relatively moderate to high compared with other areas in North America where Wolves are found. Densities in Canada range from 0.1-1.2/km² (see summary in Larson and Gunson 1983), though one area in central Alberta had a minimum density of 3.5 colonies/km² (Larson and Gunson 1983). Densities on the Kenai Peninsula in southern Alaska were less than 0.02/km² (Peterson et al. 1984), but on Isle Royale, Michigan, they ranged from 0.15-0.53/km² over a period of 20 years (Shelton and Peterson 1983).

Little information is available concerning beaver colony densities in or near our study area. During 1941-1956, aerial counts in two townships within the BSA (complete coverage; search time = 0.3-0.5 min/km²) indicated a density of only 0.09 colonies/km² (Longley and Moyle 1963). Payne (1981), however, indicated that even with a higher search rate of 0.9 min/km², 30% of colonies were missed in Newfoundland. With our search rates of 1.6-2.3 min/km², we believe we missed few, if any, colonies.

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Literature Cited

- Bergerud, A. T., and D. R. Miller.** 1977. Population dynamics of Newfoundland beaver. *Canadian Journal of Zoology* 55: 1480-1492.
- Frenzel, L. D.** 1974. Occurrence of moose in food of wolves as revealed by scat analyses: a review of North American studies. *Le Naturaliste canadien* 101: 467-479.
- Fritts, S. H., and L. D. Mech.** 1981. Dynamics, movements, and feeding ecology of a newly protected wolf population in northwestern Minnesota. *Wildlife Monographs* 80: 1-79.
- Fuller, T. K., and D. M. Heisey.** 1986. Density-related changes in winter distribution of showshoe hares and northcentral Minnesota. *Journal of Wildlife Management* 50: 261-264.
- Gunson, J. R.** 1970. Dynamics of the beaver of Saskatchewan's northern forest. M.Sc. thesis, University of Alberta, Edmonton. 122 pp.
- Hay, K. G.** 1958. Beaver census methods in the Rocky Mountain region. *Journal of Wildlife Management* 22: 395-402.
- Hill, E. P.** 1982. Beaver. Pages 256-281 in *Wild mammals of North America — biology, management and economics*. Edited by J. A. Chapman and G. A. Feldhamer. The Johns Hopkins University Press, Baltimore, Maryland.
- Karns, P. D.** 1975. Aerial beaver census. 1974. *Minnesota Wildlife Research Quarterly* 34: 199-202.
- Larson, J. S., and J. R. Gunson.** 1983. Status of the beaver in North America. *Acta Zoologica Fennica* 174: 91-93.
- Longley, W. H., and J. B. Moyle.** 1963. The beaver in Minnesota. Minnesota Department of Conservation, Division of Game and Fish. Technical Bulletin No. 6. 87 pp.
- Maycock, P. F., and J. T. Curtis.** 1960. The phytosociology of boreal coniferous-hardwood forests in the Great Lakes region. *Ecological Monographs* 30: 1-35.
- Moody, J. J.** 1979. Relationship of white-tailed deer to plant communities in northern Minnesota: vegetation inventory of the Bearville Study Area. *Minnesota Wildlife Research Quarterly* 39: 1-60.
- Payne, N. F.** 1981. Accuracy of aerial censusing for beaver colonies in Newfoundland. *Journal of Wildlife Management* 45: 1014-1016.
- Peterson, R. O., J. D. Woolington, and T. N. Bailey.** 1984. Wolves of the Kenai Peninsula, Alaska. *Wildlife Monographs* 88: 1-52.
- Pimlott, D. H., J. A. Shannon, and G. B. Kolenosky.** 1969. The ecology of the timber wolf in Algonquin Park. Ontario Department of Land and Forests Research Report (Wildlife) 87: 1-92.
- Shelton, P. C., and R. O. Peterson.** 1983. Beaver, wolf and moose interactions in Isle Royale National Park, USA. *Acta Zoologica Fennica* 174: 265-266.
- Swenson, J. E., S. J. Knapp, P. R. Martin, and T. C. Hinz.** 1983. Reliability of aerial cache surveys to monitor beaver population trends on prairie rivers in Montana. *Journal of Wildlife Management* 47: 697-703.
- Theberge, J. B., S. E. Oosenbrug, and D. H. Pimlott.** 1978. Site and seasonal variations in food of wolves. Algonquin Park, Ontario. *Canadian Field-Naturalist* 92: 91-94.
- Voight, D. R., G. B. Kolenosky, and D. L. Pimlott.** 1976. Changes in summer foods of wolves in central Ontario. *Journal of Wildlife Management* 40: 663-668.

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Observation of Late Summer Spawning Activities by the Sea Lamprey, *Petromyzon marinus*, in the Carp River, Eastern Lake Superior

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Noltie, Douglas B., and Daniel R. C. Robiliard. 1987. Observation of late summer spawning activities by the Sea Lamprey, *Petromyzon marinus*, in the Carp River, eastern Lake Superior. *Canadian Field-Naturalist* 101 (4): 599-600.

This report documents the occurrence of spawning activities by numbers of Sea Lamprey, *Petromyzon marinus*, in the Carp River, eastern Lake Superior, during late summer. Such delayed breeding attempts may have important negative implications for current control procedures.

Key Words: Sea Lamprey, *Petromyzon marinus*, spawning, breeding, reproduction, nesting, control, barrier, Lake Superior, Ontario.

In the upper Great Lakes Sea Lamprey, *Petromyzon marinus*, typically enter nursery streams as water temperatures rise and begin breeding in June (Applegate 1950; Skidmore 1959; Manion and Hanson 1980). The Carp River (46°57'N, 84°35'W), located on the eastern shore of Lake Superior, is one such tributary where this usually occurs. The river also possesses a lamprey control barrier located 1.2 km from its mouth, near which we made the following observations.

At approximately 1600 h D.S.T. on 17 August 1985, our attention was drawn by local anglers to a large congregation of adult lampreys about 100 m downstream from the barrier. On inspection, we observed a single lamprey stationed over an approximately 35-cm-wide, saucer-shaped depression. This excavation was cleaned of silt, composed of uniform pea-sized gravel (the largest available in the vicinity), and was located in slowly flowing water at mid-stream at a depth of about 75 cm. Sea Lamprey nests of this description in similar habitat have been reported from the neighbouring Pancake River (Skidmore 1959). Several similar depressions, which appeared to be incomplete, occurred directly upstream. We also observed a cluster of approximately 30 other lampreys immediately downstream of the first, intertwined and squirming vigorously beneath the overhang of a submerged log. The sexes of the individuals could not be distinguished. All were approximately 40 to 50 cm in length and were dusky brown with dark mottled dorsal surfaces. Similar sized individuals made up the 1985 spring spawning run of adult Sea Lampreys in the Carp River, with males averaging 44.2 cm and females 43.7 cm total length (R. B. McDonald, Sea Lamprey Control

Centre, Sault Ste. Marie, Ontario P6A 1P0, personal communication). River temperatures averaged 16.6°C this day, and were on a seasonal decline.

On closer approach, the majority of the lampreys fled, seeking shelter among submerged tree roots nearby. One of the few remaining was pinned to the substrate with a forked stick for identification, but was not captured. This immobilization enabled us to see that it possessed two distinct dorsal fins and a large oral disc. These distinguishing characteristics, together with the length and coloration of the individuals, support the species designation *P. marinus* (Scott and Crossman 1973). Attempts to net or photograph specimens later in the day were unsuccessful; the lamprey had abandoned the site. Intermittent surveys of the stream before and after this sighting provided no other such observations.

These observations are of twofold importance. First, although eggs were not observed in the nest (either because we disturbed the spawners prior to egg deposition or because their tiny eggs were hidden among the gravel) and specimens could not be taken to assess their sexual maturity, the behaviours observed and nest presence indicate that spawning was imminent (Applegate 1950; Wigley 1959; Manion and Hanson 1980). Even though spawning-run Sea Lamprey have been captured in the neighbouring Pancake River as late as mid-September (Skidmore 1959), solitary spent males have been found in other adjacent streams in mid-September (J. G. Weise, SLCC, personal communication), and small numbers of adults and nests containing eggs have been observed at similar times in Minnesota tributaries of Lake Superior (H. A. Purvis, U.S. Fish and Wildlife Service, Marquette Biological Station, Marquette,

MI 49855, personal communication); never before to our understanding have observations of spawning activities by such substantial numbers of Sea Lamprey been reported so late in the year.

Second, lamprey barriers like that on the Carp River have been constructed on selected lamprey nursery streams as a partial alternative to chemical control procedures (Hunn and Youngs 1980; Smith and Tibbles 1980). For such barriers to remain effective, they must not become submerged during the Sea Lamprey spawning run. However, occasional floods during the late summer and autumn of 1984 and 1985 completely swamped the Carp River barrier. Should this occur in the presence of spawning Sea Lamprey such as those reported herein, their access to upstream spawning grounds could substantially reduce barrier effectiveness.

The origin of such large numbers of late spawning Sea Lamprey is of interest: late "pulses" of spawners have been recorded in other populations (Applegate 1950; Skidmore 1959), but one of this magnitude is unusual. It is possible that these were stragglers from the spring run, the occurrence of a time lag between spawning migration and sexual maturation in some strains having been hypothesized by Larsen (1980). Alternately, adult *P. marinus* may have been transported to the river's vicinity by the adult Pink Salmon, *Oncorhynchus gorbuscha*, which began their spawning run only eight days after this observation was made. It is also possible that Sea Lamprey from the typically large and somewhat delayed spawning run from the St. Mary's River (joining lakes Superior and Huron approximately 78 km to the south) had been forced to seek adjacent streams due to flow reduction caused by remedial works occurring there, thus augmenting an already existing phenomenon in the Carp River (H. A. Purvis, personal communication). Whatever the case, this observation suggests that Sea Lamprey may be more plastic in their reproductive ecology than previously thought.

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Literature Cited

- Applegate, V. C. 1950. Natural history of the sea lamprey, *Petromyzon marinus*, in Michigan. United States Fish and Wildlife Service Special Scientific Report. Fisheries Number 55. xii + 237 pp.
- Hunn, J. B., and W. D. Youngs. 1980. Role of physical barriers in the control of sea lamprey (*Petromyzon marinus*). Canadian Journal of Fisheries and Aquatic Sciences 37(11): 2118-2122.
- Larsen, L. O. 1980. Physiology of adult lampreys, with special regard to natural starvation, reproduction, and death after spawning. Canadian Journal of Fisheries and Aquatic Sciences 37(11): 1762-1779.
- Manion, P. J., and L. H. Hanson. 1980. Spawning behavior and fecundity of lampreys from the upper three Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 37(11): 1635-1640.
- Scott, W. B., and E. J. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada Bulletin No. 184. xviii + 966 pp.
- Skidmore, J. F. 1959. Biology of spawning-run sea lamprey (*Petromyzon marinus*) in the Pancake River, Ontario. M.Sc. thesis, University of Western Ontario, London, Ontario. ix + 88 pp.
- Smith, B. R., and J. J. Tibbles. 1980. Sea lamprey (*Petromyzon marinus*) in Lakes Huron, Michigan, and Superior: history of invasion and control, 1936-78. Canadian Journal of Fisheries and Aquatic Sciences 37(11): 1780-1801.
- Wigley, R. L. 1959. Life history of the sea lamprey of Cayuga Lake, New York. United States Fish and Wildlife Service Fishery Bulletin 59(154): 561-617.

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Territorial Displacement in the American Coot, *Fulica americana*, in Response to Pond-Drying

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Sutherland, James M. 1987. Territorial displacement in the American Coot, *Fulica americana*, in response to pond-drying. *Canadian Field-Naturalist* 101 (4): 601-603.

An American Coot (*Fulica americana*) pair successfully fledging young displaced another successful pair from its territory in response to pond-drying. This observation suggests that nesting cover rather than food limits coot nesting density.

Key Words: American Coot, *Fulica americana*, territory, Saskatchewan.

Among birds using territories for feeding, nesting, and brood-rearing, there are few reports of one successful nesting pair displacing another successful pair from its territory. Such displacements must occur during the brood-rearing period, because reproductive failure would result when displacement occurs during laying or incubation. Because the American Coot, *Fulica americana*, is semi-nidifugous, brood survival is possible when displacement from the nesting territory occurs after the eggs hatch.

A variety of factors can cause territory shifts. Intrusion pressure caused boundary shifts in the feeding territories of Black-chinned Hummingbirds, *Archilochus alexandri* (Norton et al. 1982). Territory-holders expanded into territory of conspecific neighbours or completely displaced them, as

documented for breeding Great Tits, *Parus major* (Krebs 1971). In the coot, intraspecific conflicts are usually the cause of territory boundary shifts as described by Gullion (1953) for the American Coot and by Kornowski (1957) for the Eurasian Coot, *Fulica atra*. This note documents territorial displacement caused by pond-drying in a study of American Coot reproductive ecology completed in 1981-1982 near Meacham, Saskatchewan (52°10'N, 105°50'W).

In 1981, territory sizes of four pairs of nesting coots were determined about three weeks after hatching using data collected during 11 hours of observation on 5-7 July. All four pairs were observed with young. Five of the eight adults were neck-banded 21-34 days before observation. Four of the marked birds were

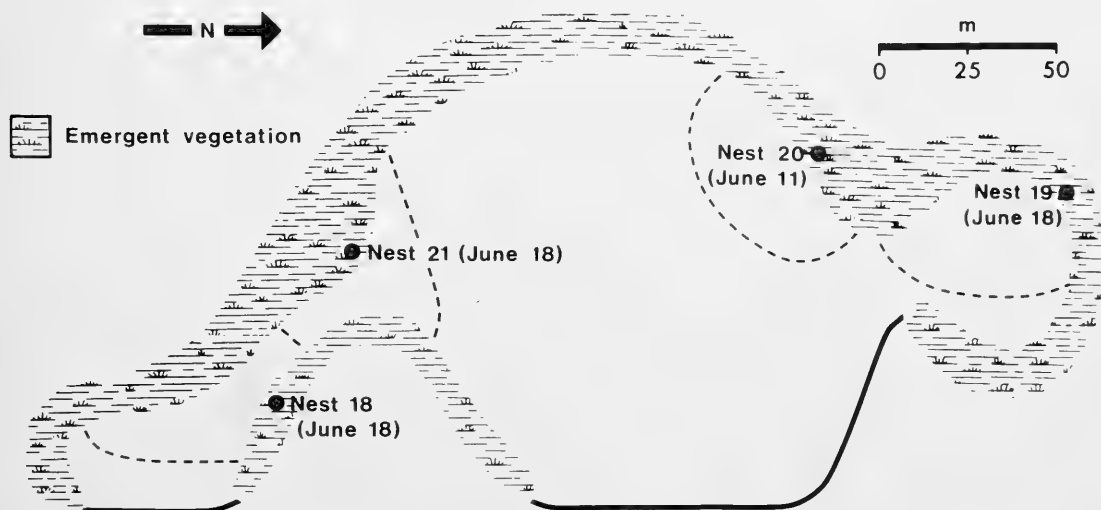


FIGURE 1. Estimated coot territories 15 June 1981. Hatching dates in parentheses.

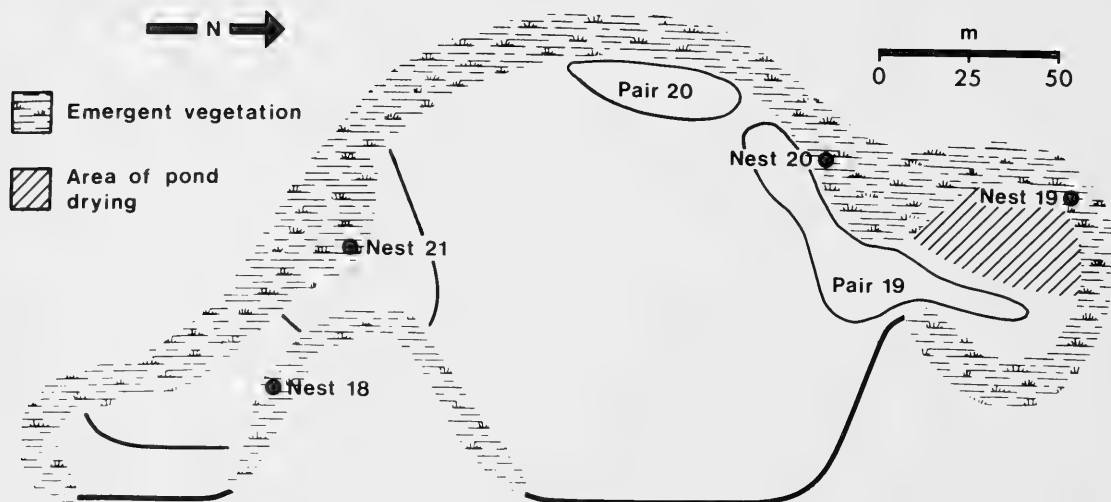


FIGURE 2. Observed coot territories 5-7 July 1981.

males and the identity of the three unmarked females was determined by their proximity to the males.

Territory boundaries of the four pairs were not determined during laying or incubation. Estimates of territory size on 15 June were determined from coot activities in July and from the fact that coot territories always include the nest (Figure 1). Territory sizes in July were determined by plotting the outermost locations of pair members and the positions of territorial encounters. From south to north, territory sizes on 5-7 July were 0.07, 0.07, 0.03, and 0.08 ha, respectively (Figure 2).

An obvious territory shift took place between 18 June, when nest 19 hatched, and early July. Pair 19 shifted its territory in early July when most of their estimated territory in mid-June became unusable as the pond dried. This displaced pair 20 from its territory. Since these territories were newly formed, territorial conflicts were expected, but none was observed. The territorial boundaries of pairs 19 and 20 had probably been determined by the time of the first observation on 5 July. Because these territories did not abut, conflicts were eliminated. There were territorial conflicts between pairs 18 and 21, as their territories were contiguous.

The displaced pair, pair 20, was able to obtain sufficient food to fledge young. Thus, nesting cover rather than food had probably limited the number of nesting pairs on the pond. Although emergent vegetation was available northeast of nest 21 and along the west side of the pond, only a narrow strip

(< 2 m) was in water. Coots seldom nest this close to shore. The amount and distribution of emergent aquatic vegetation play a key role in determining the number of nesting coots on a pond (Gullion 1953 and Sugden 1979). In many of the ponds of my study, large areas of open water were not used by coots for feeding or brood rearing. My observations and the work of Gullion (1953) and Sugden (1979) suggest that much of the food in ponds was not used by coots because nesting cover restricted their distribution and density.

Displacement of American Coots from their territory by another coot pair due to loss of pond area from drying has not been documented. This can be attributed in part to the low incidence of coots nesting on ponds subject to drying (Sugden 1979). Coots have shifted their territories in response to lowering of water levels, but displacement of another pair was not observed (Gullion 1953).

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Literature Cited

Gullion, G. W. 1953. Territorial behaviour of the American Coot. *Condor* 55: 169-186.

- Kornowski, G.** 1957. Beiträge zur Ethologie des Blässhuhns (*Fulica atra* L.). Journal für Ornithologie 98: 318–355. [Contributions to the ethology of the European Coot. Translation, TR-GER-16, Canadian Wildlife Service, Ottawa.]
- Krebs, J. R.** 1971. Territory and breeding density in the Great Tit (*Parus major*). Ecology 52: 2–22.
- Norton, M. E., P. Arcese, and P. W. Ewald.** 1982. Effect of intrusion pressure on territory size in Black-chinned Hummingbirds (*Archilochus alexandri*). Auk 99: 761–764.
- Sugden, L. G.** 1979. Habitat use by nesting American Coots in Saskatchewan parklands. Wilson Bulletin 91: 599–607.
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Interactions of Wolves, *Canis lupus*, and Brown Bears, *Ursus arctos*, at a Wolf Den in the Northern Yukon

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Hayes, Robert D., and David H. Mossop. 1987. Interactions of Wolves, *Canis lupus*, and Brown Bears, *Ursus arctos*, at a Wolf den in the northern Yukon. Canadian Field-Naturalist 101 (4): 603–604.

Two encounters between Wolves (*Canis lupus*) and Brown Bears (*Ursus arctos*) were observed at the same Wolf den in the northern Yukon. One involved Brown Bears digging at the entrance of the den. The second was a short encounter between Brown Bears and a single Wolf that was disturbed by another Brown Bear.

Key Words: Wolf, *Canis lupus*, Brown Bear, *Ursus arctos*, Wolf den, Yukon Territory.

Encounters between Wolves (*Canis lupus*) and Brown Bears (*Ursus arctos*) at wolf dens have been reported from Denali Park, Alaska (Murie 1944), and, more recently, from the Kenai Peninsula, Alaska (Peterson et al. 1984). This note describes two observations of Wolf and Brown Bear interactions at the same Wolf den site in the northern Yukon Territory, and discusses the Brown Bear as a potential predator of Wolf pups.

On 10 June 1976, while conducting aerial surveys of wildlife in the Babbage River drainage 138° 40'W, 68° 50'N in the northern Yukon, we observed a light-coloured sow Brown Bear and two young, estimated at 2–3 years of age, digging at the entrance of an occupied Wolf den. The bears were surrounded by seven Wolves less than two meters away. The Wolves were clearly attempting to defend the den. As the helicopter passed over the den, several Wolves were seen attacking the Bears. The helicopter caused the bears to run from the den entrance, and as the bears left the den, the sow charged the surrounding Wolves, then ran uphill, followed by her young. The Wolves chased them for about 300 meters, leaping and biting at the bears. One Wolf bit a bear cub on the shoulder and was carried about 10 meters before it was

released. The sow periodically stopped and charged the Wolves and then continued running. The Wolves followed the bears to a ridge 400 meters from the den. At this point, we left the area, and returned to check the den on 9 August. Numerous pup-sized scats were located in the denning area, indicating that pups were raised and were present at the den on 19 June. The fate of the pups was never determined.

A second interaction was observed at the same den site on 23 June 1980. Like the first one, this observation was initially made from a helicopter. A light-coloured sow and two young, 2 or 3 years old, were observed lying 5 m from the entrance to the same Wolf den. A single Wolf stood between the bears and the den and was apparently defending the entrance. We immediately turned away from the area to avoid additional disturbance. We landed on a hillside 800 m away and continued observing with binoculars. The bears and Wolf were apparently not disturbed by the helicopter, and remained in the same positions for about 10 minutes.

During this period, a band of 25 Barren Ground Caribou (*Rangifer tarandus groenlandicus*) travelled along the river bank, moving uphill toward the den, apparently undetected by the bears or Wolf. The band

approached to within 30 m of the den but remained below and out of sight. Suddenly, another, larger, dark Brown Bear charged the band from a willow (*Salix sp.*) thicket about 50 meters downstream. The Caribou immediately fled uphill toward the den, followed by the Bear. The other bears and Wolf at the den scattered as the Caribou and hunting Bear passed the den area and then disappeared over a ridge. The sow and cubs regrouped about 300 meters upstream and moved slowly away from the den. The single Wolf returned to the den entrance and lay down. We continued watching for another five minutes and then departed. We did not determine if Wolf pups were present during this observation or if any were raised in 1980.

The presence of bears at the den site can be interpreted in two ways: they were attracted by the smell of carrion and were attempting to scavenge carrion cached in the den entrance, or the bears were attempting to prey upon Wolf pups inside the den. In Denali Park, Alaska, a sow Brown Bear with two yearling cubs were observed digging at an occupied Wolf den and feeding on cached carrion (Murie 1944). Peterson et al. (1984) reported a pack of nine Wolves holding off a large Brown Bear 100 m from their den. Ballard (1982) interpreted the aggressive behaviour of Wolves toward a lone Brown Bear two kilometers from a south-central Alaska Wolf den as a successful attempt to displace the bear from their den. In 1986 Whitten (personal communication) observed two Wolves attacking a Brown Bear at a productive den in the Arctic National Wildlife Refuge, Alaska. In the same area, Weiler (personal communication) has observed Wolves defending a productive den from two Brown Bears, and a single Wolf chasing a Brown Bear away from a den containing pups.

In our first observation, the digging behaviour of the bears in the den entrance, and the presence of pup scats at the den in August, suggest that the bears were attempting to dig out pups hidden in the den cavity. Previous papers have reported a Brown Bear killing an adult Wolf (Ballard 1980), Wolves killing a yearling Brown Bear (Ballard 1982), a Black Bear (*Ursus americanus*) killing a Wolf (Joslin 1966 in Rogers and Mech 1981), and Wolves killing dunned Black Bears (Rogers and Mech 1981; Horesji et al. 1984; Paquet and Carbyn 1986). While these reports do not suggest that Wolves and bears selectively hunt

each other, given the opportunity, Wolves and bears will clearly kill each other.

Peterson et al. (1984) speculated that the greatest threat that bears pose to Wolves would be at dens containing young Wolf pups. Our observations do not confirm that Brown Bears are predators of Wolf pups, but they do show that Brown Bear maternal units can displace Wolves enough so that they can approach closely and dig at a productive den. While we did not observe Brown Bears preying on Wolf pups, persistent activity like the observations we reported could certainly result in the death of neonatal Wolves by Brown Bears.

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Literature Cited

- Ballard, W. B.** 1980. Brown Bear kills Gray Wolf. *Canadian Field-Naturalist* 94(1): 91.
- Ballard, W. B.** 1982. Gray Wolf-Brown Bear relationships in the Nelchina basin of south-central Alaska. Pp. 71-80 in *Wolves of the world: perspectives of behaviour, ecology, and conservation*. Edited by F. H. Harrington and P. C. Paquet. Noyes Publications, Park Ridge, New Jersey. 474 pp.
- Horesji, B. L., G. E. Hornbeck, and R. M. Raine.** 1984. Wolves, *Canis lupus*, kill female Black Bear, *Ursus americanus*, in Alberta. *Canadian Field-Naturalist* 98(3): 368-369.
- Joslin, P. W. B.** 1966. Summer activities of two Timber Wolf (*Canis lupus*) packs in Algonquin Park. M.Sc. thesis, University of Toronto. 99 pp.
- Murie, A.** 1944. The Wolves of Mount McKinley. Fauna of the National Parks of the United States. Fauna Series Number 5, Washington, D.C. 238 pp.
- Paquet, P. C., and L. N. Carbyn.** 1986. Wolves, *Canis lupus*, killing denning Black Bears, *Ursus americanus*, in the Riding Mountain National Park area. *Canadian Field-Naturalist* 100(3): 371-372.
- Peterson, R. O., J. D. Woolington, and T. N. Bailey.** 1984. Wolves of the Kenai peninsula. *Wildlife Monographs* 88. 52 pp.
- Rogers, L. L., and L. D. Mech.** 1981. Interaction of Wolves and Black Bears in northeastern Minnesota. *Journal of Mammalogy* 62(2): 434-436.

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Lesser Snow Geese, *Chen c. caerulescens*, Breeding in Pelly–Lower Garry Lakes Area, Interior Keewatin District, Northwest Territories

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McCormick, Kevin J., and Bradley D. Arner. 1987. Lesser Snow Geese, *Chen c. caerulescens*, breeding in Pelly–Lower Garry lakes area, interior Keewatin District, Northwest Territories. *Canadian Field-Naturalist* 101 (4): 605–606.

Adult Lesser Snow Geese (*Chen c. caerulescens*) with young in the Pelly–Lower Garry lakes area, interior Keewatin District, NWT are the first evidence of nesting in this area.

Key Words: Lesser Snow Geese, *Chen c. caerulescens*, Pelly Lake, Lower Garry Lake, Keewatin District.

We conducted a survey of moulting Canada Geese, *Branta canadensis*, on the Back River system (65°55'N, 101°20'W) in northern Keewatin District from 23 to 26 July 1984. A total of 362 adult and 55 young Lesser Snow Geese, *Chen c. caerulescens*, was observed between the Bullen–Back rivers junction and the west end of Lower Garry Lake. Many more young, intermingled with large flocks of adults, were present at Pelly Lake but could not be accurately counted.

This is the first record of breeding Lesser Snow Geese at this location which is over 80 km southeast of the nearest colony (66°45'N, 102°53'W) in the Queen Maud Gulf Bird Sanctuary (Kerbes et al. 1983).

Major inland breeding colonies of Lesser Snow Geese are rare. With the exception of the Egg River colony on Banks Island, all other large colonies are situated in previously inundated marine coastal zones. It has been postulated that the marine sediments are

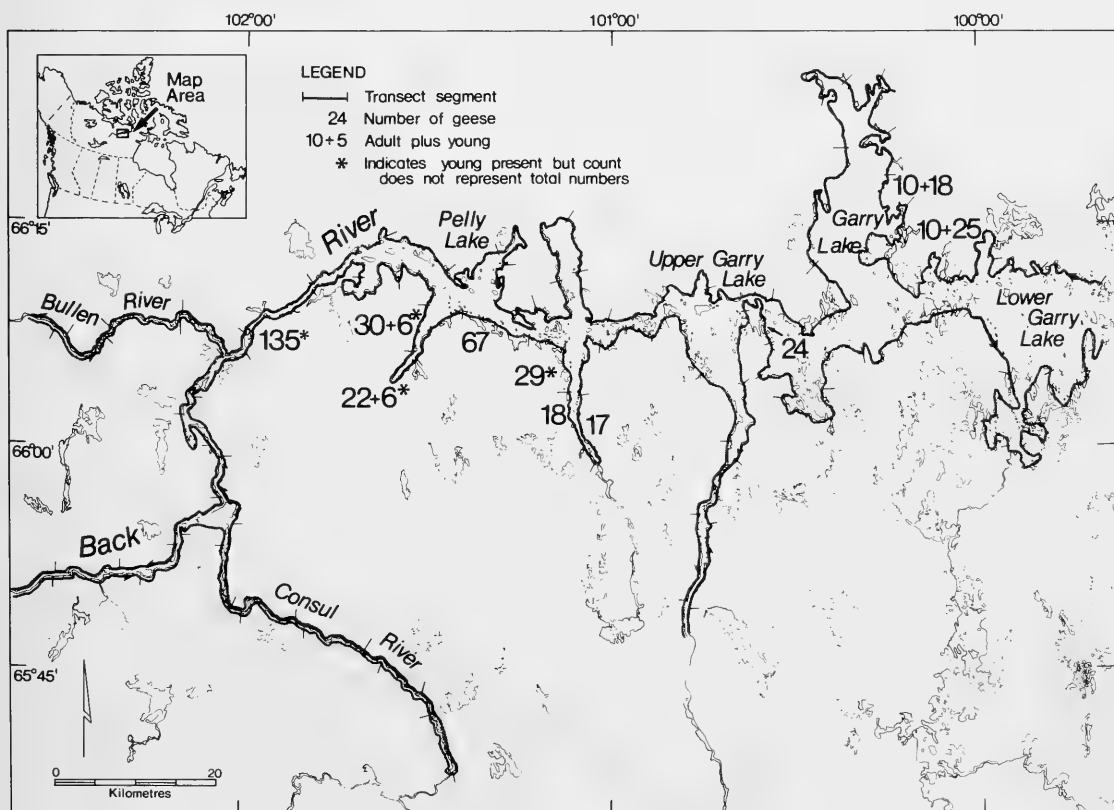


FIGURE 1. Distribution of Lesser Snow Geese in the Pelly–Lower Garry lakes area, Northwest Territories, July 1984.

conductive to the growth of nutrient-enriched sedges upon which the geese feed while rearing young (MacInnes 1966; Ryder 1969).

However, small colonies of Lesser Snow Geese have been previously recorded in interior Keewatin District. Clarke (1940: 42) encountered "a flock of adults and young on 7 August, 1937" on Beverly Lake (64°36'N, 100°30'W). During the early 1960s, T. Sterling (Ducks Unlimited, Victoria, British Columbia) recorded seven nesting sites on islands approximately 6 km west of the west end of Aberdeen Lake (64°30'N, 99°00'W). Fifty-five nests were located in 1963 and 97 nests were recorded in 1964. Kuyt (1966) also observed a colony of 30–40 pairs near the west end of Aberdeen Lake. In July 1970, Miller (1972) documented 21 nests at Kazan Falls (63°43'N, 95°51'W). Five colonies, totalling 134 nests, were also observed in the Pitz Lake–Aberdeen Lake area in the mid 1970s (P. L. McLaren and C. Holdsworth. 1978. Summer bird populations in the Pitz Lake–Baker Lake area, District of Keewatin, NWT. Unpublished report by LGL Environmental Research Associates for Polar Gas Project, Toronto. 82 pp.) All of these colonies are located over 200 km inland from marine habitats but are in areas previously inundated by post-glacial lakes (Anonymous 1967).

The Pelly–Lower Garry lakes area has a similar post-glacial history (Craig 1964). Numerous small islands occur along the margins of most of the lakes. The low-lying islands and adjacent shorelines, which support well-developed sedge meadows, are remarkably similar to the habitat of colonies in the Queen Maud Gulf Sanctuary (personal observation; Ryder

1969). On the basis of habitat features, there appears to be considerable potential for Lesser Snow Goose numbers to expand in this area.

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Literature Cited

- Anonymous. 1967. Glacial map of Canada. Map 1253A, Geological Survey of Canada, Ottawa.
- Clarke, C. H. D. 1940. A biological investigation of the Thelon Game Sanctuary. National Museum of Canada, Bulletin No. 96, Biological Series No. 25. Ottawa. 135 pp.
- Craig, B. G. 1964. Surficial geology of east-central District of Mackenzie. Bulletin Number 99, Geological Survey of Canada, Ottawa. 41 pp.
- Kerbes, R. H., M. R. McLandress, G. E. J. Smith, G. W. Beyersbergen, and B. Godwin. 1983. Ross' Goose and Lesser Snow Goose colonies in the central Canadian Arctic. Canadian Journal of Zoology 61: 168–173.
- Kuyt, E. 1966. Adjoining unusual nest sites of Snow Goose and Peregrine Falcon. Blue Jay 24: 171.
- MacInnes, C. D. 1966. Population behaviour of eastern Arctic Canada Geese. Journal of Wildlife Management 30: 536–553.
- Miller D. F. 1972. Birds nesting at Kazan Falls. Auk 89: 183–185.
- Ryder, J. P. 1969. Nesting colonies of Ross' Goose. Auk 86: 282–292.

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Nocturnal Activity of the Woodchuck, *Marmota monax*, in an Urban Park in Ohio

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Koprowski, John L. 1987. Nocturnal activity of the Woodchuck, *Marmota monax*, in an urban park in Ohio. Canadian Field-Naturalist 101(4): 606–607.

Frequent above-ground nocturnal activity of the Woodchuck was recorded in an urban park. This activity may be related to heavy human recreational use of the park.

Key Words: Woodchuck, *Marmota monax*, nocturnal activity, urban, Ohio.

Diurnal activity patterns of the Woodchuck, *Marmota monax*, have been studied (Bronson 1962; Hayes 1976); however, few studies attempt to examine nocturnal activity. An exception (Hayes 1976) found

evidence of occasional above-ground nocturnal activity until 2400 h during summer and fall. Other reports of nocturnal activity (Howell 1915; Schoonmaker 1966:87; Hamilton and Whitaker 1979:145) are

primarily anecdotal or suggest its rarity. Early researchers believed most sciurids possessed a retina adapted solely to diurnal vision. However, Tansley et al. (1961) and Green and Dowling (1975) demonstrated that the sciurid retina permits vision at low light intensities. Both ecological and physiological evidence suggest that ground squirrels are capable of nocturnal activity. I report here on the frequent above-ground nocturnal activity of Woodchucks in a metropolitan park with heavy human use during daylight hours.

Six burrow systems, each inhabited by a solitary adult, were monitored for above-ground nocturnal activity between 12 July and 14 August 1982 on 0.8 km of roadside in the Rocky River Reservation, Cleveland Metroparks System, Cuyahoga County, Ohio. Burrows were located in woodlands adjacent to a grass (*Festuca* sp.) and White Clover (*Trifolium repens*) berm associated with a two-lane roadway. Berms are heavily used by people for recreation; however, use was limited to vehicular traffic after 2300 h. All burrows were in areas of equal human use. Artificial street lighting was absent from the study area.

Burrow entrances were surrounded one hour after sunset with a 25-cm wide by 1-cm deep, slightly-dampened, sand layer 25 cm from each opening. Light-coloured sand was placed on the soil to a depth of 0.75 cm and covered by 0.25 cm of dark sand. The contrasting sand layers permitted accurate assessment of Woodchuck activity in early morning darkness. Each entrance was examined for activity (presence of Woodchuck tracks) 1.5 h before sunrise.

One hundred and six instances (3.8 ± 0.7 active burrows/night) of above-ground nocturnal activity were recorded, with activity documented on each of 29 nights. Nocturnal activity of this frequency is contrary to previous reports (Howell 1915; Schoonmaker 1966; Hayes 1976). The duration of nocturnal activity is not known; however, foraging on the berm was observed on two nights and small piles (caches?) of vegetation discovered 1 to 3 m from many entrances during evening burrow preparation were absent the following morning. These observations suggest that a biologically significant nocturnal component of daily activity includes foraging.

Because studies in rural locations have not recorded substantial nocturnal activity, I suggest that this occurrence may represent behavioral plasticity to

minimize disturbance from human use patterns. Nocturnal foraging by Woodchucks was noted in response to hunting (Hamilton and Whitaker 1979: 145), suggesting human disturbance as an important influence. Highway traffic does not influence Woodchuck activities (Manville 1966; Doucet et al. 1974) and habituation to vehicles was observed at the study site. Future studies are necessary to determine if nocturnal activity is common among the sciurids, and the actual influence of human disturbance and other factors such as ambient light and weather on nocturnal activity patterns.

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Literature Cited

- Bronson, F. H. 1962. Daily and seasonal activity patterns in woodchucks. *Journal of Mammalogy* 43: 425-427.
- Doucet, G. J., J. P. R. Sarrazin, and J. R. Bider. 1974. Use of highway overpass embankments by the woodchuck, *Marmota monax*. *Canadian Field-Naturalist* 88: 187-190.
- Green, D. G., and J. E. Dowling. 1975. Electrophysiological evidence for rod-like receptors in the gray squirrel, ground squirrel and prairie dog retinas. *Journal of Comparative Neurology* 159: 461-471.
- Hayes, S. R. 1976. Daily activity and body temperature of the southern woodchuck, *Marmota monax monax*, in northwestern Arkansas. *Journal of Mammalogy* 57: 291-299.
- Hamilton, W. J., Jr., and J. O. Whitaker, Jr. 1979. *Mammals of the eastern United States*. Comstock, Ithaca, New York. 346 pp.
- Howell, A. H. 1915. Revision of the American marmots. *North American Fauna* 37: 1-80.
- Manville, R. H. 1966. Roadside abundance of woodchucks. *American Midland Naturalist* 75: 537-538.
- Schoonmaker, W. J. 1966. *The world of the Woodchuck*. J.B. Lippincott, Philadelphia. 146 pp.
- Tansley, K., R. M. Copenhaver, and R. D. Gun-
kel. 1961. Spectral sensitivity curves of diurnal squirrels. *Vision Research* 1: 154-165.

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Comparative Efficiency of New- and Old-Style Museum Special Traps in Capturing Small Mammals

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Thompson, I. D., and A. L. Macaulay. 1987. Comparative efficiency of new and old-style Museum Special traps in capturing small mammals. *Canadian Field-Naturalist* 101 (4): 608-610.

New-style Museum Special traps with their plastic treadle were found to be more sensitive than old-style Museum Specials which have a wood/metal treadle. The new traps captured more Masked Shrews (*Sorex cinereus*) than old traps and more Deer Mice (*Peromyscus maniculatus*) than Holdfast traps.

Key Words: Soricidae, Cricetidae, small mammals, trap bias.

Kill or "snap-trapping" is a commonly used technique to study species composition and abundance of small mammals (Fowle and Edwards 1954). There are several designs of these traps available commercially but their relative efficiency may vary (Pruitt and Lucier 1958; Smith et al. 1971; Wiener and Smith 1972; Martell 1979). In long-term studies consistency in trapping methods is an important consideration. Changing of methods or trap type will introduce bias and make comparisons among years less than ideal.

The Canadian Wildlife Service conducted a study of Marten (*Martes americana*) and their small mammal prey near Manitouwadge, Ontario (49° 20'N, 85° 50'W), from 1980-85. Owing to changes in the trap design of Museum Special traps by the manufacturer (Woodstream Corporation, Niagara Falls, Ontario), we had to test for differences in capture efficiency between old- and new-style traps. These traps can last many years, and so the problem is one faced by any researcher requiring new traps during a study and who therefore needs to compare results with other studies conducted with different traps.

Methods

Three types of traps were used in this study: 1) the old Museum Special which has dimensions of 69 × 141 mm and a wood/metal treadle (12 × 26 mm); 2) the new Museum Special which is the same size but has a larger plastic treadle measuring 30 × 33 mm; and 3) the Holdfast trap which is 48 × 99 mm with an 11 × 16 mm wood/metal treadle. Sensitivity of the treadles was measured after Martell (1979).

Two broad habitats were studied: upland mixed woods and a lowland-mesic Black Spruce (*Picea mariana*) type. Sites were chosen in 2, 10, 20, and 30 year-old cutovers as well as in uncut areas. Paired lines consisting of 25 stations with 15-m spacing

between stations were placed 1-km apart or at 180° to each other. Each station consisted of one Museum Special and one Holdfast trap baited with peanut butter, with new Museum Specials on one line and old traps on the other. Lines were checked daily for three days and then removed. Trapping was conducted in May and September from 1982 to 1984. Approximately 9000 trap nights (one trap set for 24 hrs = one trap night) were accumulated for each type of Museum Special and 18 000 trap nights for Holdfasts.

All sites for a given year were combined for analysis. We first examined the data for total number of animals caught and species composition across the three types of trap using ANOVA with stabilized variance. Comparisons between trap types for species with large ($N \geq 50$) samples, total captures per 100 trap nights, and number of snapped empty traps were performed using paired T-tests. For those species where the sample was small ($N \leq 50$), we used binomial tests for comparisons. Statistical methods followed Siegel (1956) and Sokal and Rohlf (1981) and were performed using Minitab (Ryan et al. 1982).

The old Museum Special-Holdfast pairing permitted examination of results achieved by Martell (1979) from the same general study area.

Results and Discussion

The ANOVA among years revealed a consistent pattern of catch by trap type and showed that pairings of trap types had no effect on total captures. Therefore, all years were combined for further analysis.

Sensitivity of traps was the same as reported by Martell (1979) for old Museum Special (1.8 ± 0.08 g) and Holdfast traps (3.9 ± 0.24 g). However, the new Museum Special traps were more sensitive (1.1 ± 0.02 g) than either of these two traps ($P \leq 0.05$).

TABLE 1. Summary of captures for species of small mammals trapped according to trap type and pairing, Manitouwadge, Ontario, 1982–1984. (MS = Museum Special, H = Holdfast).

	Pair		Pair		Total	
	Old MS	H	New MS	H	MS	H
<i>Peromyscus maniculatus</i>	177	150	210	139	387	289
<i>Clethrionomys gapperi</i>	80	72	95	60	175	132
<i>Sorex cinereus</i>	40	35	82*	49	122	84
<i>Blarina brevicauda</i>	17	6	9	9	26	15
<i>Eutamias minimus</i>	14	6	7	6	21	12
<i>Microtus pennsylvanicus</i>	8	6	12	5	20	11
<i>Microtus chrotorrhinus</i>	5	1	1	5	6	6
<i>Napaeozapus insignis</i>	4	0	5	1	9	1
Other ¹	19	6	14	6	33	12
Total animals	364	282	435*	280	799	582

¹Other includes *Phenacomys intermedius*, *Synaptomys cooperi*, *Sorex arcticus*, *S. palustris*, *Zapus hudsonius*, and *Tamias striatus*.

*Old vs New comparison, $P \leq 0.01$.

The new Museum Special traps caught more animals in total, more Masked Shrews (*Sorex cinereus*) (Table 1), and more species (1.72 ± 0.14 [SE] vs 1.36 ± 0.14 [SE], $P \leq 0.05$) compared to old-style. All other species were trapped at the same rate in the two types of Museum Special. The greater number of Masked Shrews (average weight approximately 4 g) undoubtedly reflects the greater sensitivity of the new Museum Special trap. When Masked Shrews were removed from the analyses, there was no significant difference in total animals caught or in the number of species occurring in the two Museum Special types.

Use of the new traps produced fewer trap nights (average number of traps snapped = 6.5 vs 11.6 per 100 trap nights for old and new types, respectively) ($P \leq 0.001$). This resulted because the larger, more sensitive plastic treadle of the new trap was easily set off by rain or dew dripping from vegetation. Furthermore, unless the new traps were coated with varnish, the spring mechanism broke if the trap was subjected to several successive rainy days.

We were unable to duplicate the results of Martell (1979) which suggested that a small trap was more effective in capturing smaller animals. We saw no difference in the number of captures of Masked Shrews in the old Museum Special-Holdfast pairing and more shrews were taken in new Museum Specials compared to Holdfasts. Also, there was no significant difference among the trap types in captures of Least Chipmunks (*Eutamias minimus*), the only large species caught regularly. We believe that the higher sensitivity of Museum Special traps was important in taking small shrews. As noted by Martell, sensitivity was also implicated by Smith et al. (1971) and Wiener and Smith (1972) in effective capture rates.

Deer Mice (*Peromyscus maniculatus*) were captured more frequently in new Museum Specials than in Holdfasts. This was not true of old traps from our data or those of Martell (1979). Again, we believe the greater sensitivity was responsible. On numerous occasions, the bait in the Holdfast was eaten and the trap was unsprung, while the new Museum Special of the pair contained a Deer Mouse.

Our data suggest that the only bias between old- and new-style Museum Special traps was in capture rate of Masked Shrews. Also, the new Museum Special trap is a more effective trap for both Masked Shrews and Deer Mice compared to the Holdfast, and is equally efficient for all other species. Pairing the large and small traps was found to be irrelevant, and mixing old and new Museum Special traps will only affect species composition results marginally. Correction factors could be added for Masked Shrews. The tendency of new-style traps to snap in the rain will produce incorrect estimates of abundance when populations of small mammals are high.

Museum Special traps cost \$3 Canadian (in 1983); we therefore recommend the use of varnish or heated Lion oil to reduce breakage.

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Literature Cited

Fowle, C. D., and R. Y. Edwards. 1954. The utility of break-back traps in population studies of small mammals. *Journal of Wildlife Management* 18: 503–508.

- Martell, A. M.** 1979. Relative efficiencies of Museum Special, Victor, and Holdfast traps for sampling small mammal populations. *Canadian Field-Naturalist* 93: 313-315.
- Pruitt, W. O., and C. V. Lucier.** 1958. On the relative efficiency of two kinds of traps. *Journal of Mammalogy* 39: 157.
- Ryan, T. A., B. L. Joiner, and B. F. Ryan.** 1982. Minitab reference manual. Duxbury Press, Boston. 154 pp.
- Siegel, S.** 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., New York. 312 pp.
- Smith, G. C., D. W. Kaufman, R. M. Jones, J. B. Gentry, and M. H. Smith.** 1971. The relative effectiveness of two types of snap traps. *Acta Theriologica* 16: 284-288.
- Sokal, R. R., and F. J. Rohlf.** 1981. Biometry. W. H. Freeman and Co., San Francisco. 859 pp.
- Wiener, J. G., and M. H. Smith.** 1972. Relative efficiencies of four small mammal traps. *Journal of Mammalogy* 53: 868-873.

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Joint Nest-Building Activity in the Eastern Gray Squirrel, *Sciurus carolinensis*

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Koprowski, John L., and Nancy M. Koprowski. 1987. Joint nest-building activity in the Eastern Gray Squirrel, *Sciurus carolinensis*. *Canadian Field-Naturalist* 101 (4): 610-611.

A male and female Eastern Gray Squirrel were observed sharing in the building of a leaf nest.

Key Words: Eastern Gray Squirrel, *Sciurus carolinensis*, nests, co-operation, Kansas.

The Eastern Gray Squirrel, *Sciurus carolinensis*, nests arboreally throughout its range in southern Canada and the eastern United States. Two types of natural nest sites are frequently used: den cavities and leaf nests (Brown and Yeager 1945). Leaf nests or dreys generally consist of a platform constructed from twigs, an outer shell of leaves and twigs, and usually an inner shell of shredded bark, grass or other tightly woven vegetation (Fitzwater and Frank 1944). Leaf nests are situated at limb forks of branches and along the trunks of trees often supported by vines which anchor the structure (Sanderson et al. 1980). Eastern Gray Squirrels, especially females nursing young, may prefer the more permanent den cavities (Packard 1956).

On 20 April 1986 between 1530 and 1830 h using 7 × 35 mm binoculars we observed two Eastern Gray Squirrels building a leaf nest in urban Lawrence, Douglas County, Kansas. An adult male (> 1 year) was distinguishable by the black scrotal pigmentation and descended scrotal testes (for review see Larson and Taber 1980). The second squirrel was a female as evidenced by the proximity of the urogenital opening to the anus. Both squirrels were similar in size and larger than spring-born juveniles; however, we were unable to determine whether the female was a

subadult (born summer 1985) or adult, because it lacked black teats indicative of previously-bred adult females.

The leaf nest was located 13 m high in a Honey Locust (*Gleditsia triacanthos*) with a 40-cm DBH (diameter at breast height). The remnants of a previous leaf nest entangled in Virginia Creeper (*Parthenocissus quinquefolia*) and Trumpet Creeper (*Campsis radicans*) vines served as a foundation.

The male collected only Honey Locust leaves and the female selected only Hackberry (*Celtis occidentalis*) leaves. Each squirrel continually used the same route when exiting and returning to the leaf nest. We never observed either squirrel using an alternate route although more direct routes were present. We estimate the rate of leaf collection for each squirrel was 1.5 leaves/minute, suggesting more than 500 leaves were gathered for construction. Nest construction appeared to terminate with darkness.

The squirrels were frequently in the nest simultaneously and neither agonistic nor amicable behavior was noted. Eastern Gray Squirrels and other tree squirrels are considered to be relatively asocial (Heaney 1984). Although concurrent, nocturnal nest-sharing has been occasionally documented (Bakken 1952; Cordes and Barkalow 1972), this is the first

account of two squirrels co-operating in building a leaf nest.

Copulation occurs following intense mating bouts in which males compete for access to an estrous female; the sexes separate soon after copulation (Thompson 1977). Because the female did not exhibit the enlarged vulva indicative of estrus, we do not believe this nest-building behavior related to breeding activity.

Literature Cited

- Bakken, A. A.** 1952. Interrelationships of *Sciurus carolinensis* (Gmelin) and *Sciurus niger* in mixed populations. Ph.D. thesis, University of Wisconsin, Madison, Wisconsin.
- Brown, L. G., and L. E. Yeager.** 1945. Fox squirrels and gray squirrels in Illinois. *Bulletin of the Illinois Natural History Survey* 23: 449–536.
- Cordes, C. L., and F. S. Barkalow, Jr.** 1972. Home range and dispersal in a North Carolina gray squirrel population. *Proceedings of the Southeastern Association of Game and Fish Commissioners* 26: 124–135.
- Fitzwater, W. D., Jr., and W. J. Frank.** 1944. Leaf nests of gray squirrels in Connecticut. *Journal of Mammalogy* 25: 160–170.
- Heaney, L. R.** 1984. Climatic influences on life-history tactics and behavior of North American tree squirrels. Pages 43–78 in *The biology of ground-dwelling squirrels*. Edited by J. O. Murie and G. R. Michener. University of Nebraska, Lincoln. 459 pp.
- Larson, J. S., and R. D. Taber.** 1980. Criteria of sex and age. Pages 143–202 in *Wildlife techniques manual*. Edited by S. D. Schemnitz. Wildlife Society, Washington. 686 pp.
- Packard, R. L.** 1956. The tree squirrels of Kansas: ecology and economic importance. University of Kansas Museum of Natural History Miscellaneous Publication 11: 1–67.
- Sanderson, H. R., C. M. Nixon, R. W. Donohoe, and L. P. Hansen.** 1980. Grapevines — an important component of gray and fox squirrel habitat. *Wildlife Society Bulletin* 8: 307–310.
- Thompson, D. C.** 1977. Reproductive behavior of the grey squirrel. *Canadian Journal of Zoology* 55: 1176–1184.

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Occurrence of the Northern Bog Lemming, *Synaptomys borealis*, in the Northeastern United States

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Clough, Garrett C., and John J. Albright. 1987. Occurrence of the Northern Bog Lemming, *Synaptomys borealis*, in the northeastern United States. *Canadian Field-Naturalist* 101 (4): 611–613.

Three new specimens of the Northern Bog Lemming (*Synaptomys borealis*) from Maine and one misidentified record from New Hampshire are reported here. This brings the total specimens of *S. borealis* for the northeastern United States to seven. The species is not restricted to scarce alpine habitat in this region nor is it unable to coexist with related microtine species. Reasons for its rarity remain obscure.

Key Words: Northern Bog Lemming, *Synaptomys borealis*, rarity, Maine, New Hampshire.

The Northern Bog Lemming, *Synaptomys borealis*, is rare in mammal collections in the United States. In the northeastern U.S. only three *Synaptomys borealis* specimens had been recorded prior to the work reported here. The first specimen in the U.S. was collected in 1898 near the base of Mt. Washington, Coos County, New Hampshire (Preble 1899). This is the type for the subspecies *S. b. sphagnicola*. Two more specimens were collected in 1902 from the alpine zone of Mt. Katahdin, Piscataquis County, Maine (Dutcher 1903). Nine subspecies have been described throughout this species' range in Canada and the

northern U.S. (Hall and Kelson 1981; Banfield 1974).

This paper reports the occurrence of three new *S. b. sphagnicola* specimens collected in Maine in 1985 and documents a fourth specimen from New Hampshire which had been misidentified. New information on habitat and small mammal associates is included.

We collected three new specimens of Northern Bog Lemming in two separate localities within Baxter State Park, Piscataquis County, Maine. The first location was on the alpine tableland of Mt. Katahdin at 1375 meters elevation (69°00'W, 45°53'N). The second location was at the western border of the park

in a stand of Spruce-Budworm killed spruce and fir trees at 400 meters elevation. We based identification primarily on the enamel patterns of the lower molar teeth as in Howell (1927). All of our specimens were compared with both skins and skulls of *S. borealis* and *S. cooperi* (Southern Bog Lemming) at the Museum of Comparative Zoology, Harvard University.

At the high elevation site 39 Sherman live traps and 36 pit traps (66 mm diameter by 120 mm deep) were set for three nights (18–20 July 1985). The traps were set in an open area of alpine sedge meadow below a running spring named Caribou Springs, and at the edge of dense Krummholz habitat surrounding the open meadow. This spring was the precise place where Dutcher (1903) had collected the two specimens in 1902. The sedge meadow habitat was dominated by sedge (*Carex* spp.), sphagnum moss, lichen (*Cetraria nivalis*) and dwarf shrubs (*Salix uva-ursi* and *Betula glandulosa*). The Krummholz consisted of Black Spruce (*Picea mariana*), Balsalm Fir (*Abies balsamifera*), and dwarf birch (*Betula minor* and *B. glandulosa*).

The second collecting site was approximately 9.1 km away from Caribou Springs and separated by a valley and range of mountains 1000 to 1250 m high. The habitat and small mammals of this area were studied in 1982 and described by Clough (1987). The understory at this site was dominated by fir, spruce, Mountain Ash (*Sorbus americana*) and Paper Birch (*Betula papyrifera*) up to 2 m high. The shrub and ground layers consisted of dense growth of raspberry (*Rubus* sp.), ferns, some grass, and sedge and sphagnum moss in scattered damp places. Many downed tree trunks, some of which were old and moss-covered, criss-crossed the ground. All canopy trees were dead. Most of the ground was dry in July and August.

Results and Discussion

In the Mt. Katahdin alpine site, two *S. borealis* were captured in the sedge meadow habitat: an immature female and a pregnant female with four embryos. Both were captured in pitfall traps. The other small mammals collected here were *Microtus pennsylvanicus* (Meadow Vole) (2), *Clethrionomys gapperi* (Southern Red-backed Vole) (1), *Peromyscus maniculatus* (Deer Mouse) (4), *Blarina brevicauda* (Short-tailed Shrew) (1), and *Sorex cinereus* (Masked Shrew) (9). Additional trapping efforts in two wet grass meadows at elevations of 890 m (40 TN) and 855 m (50 TN) on Mt. Katahdin yielded no bog lemmings. A trap night (TN) is one trap set for 24 hours.

In the low elevation spruce-fir forest site during 1982 no *S. borealis* were caught with 360 TN,

although 72 other small mammals were captured. Two separate trapping efforts occurred here in 1985: 4–6 July (135 TN, Longworth live traps), and 7–11 August (300 TN, snap traps). No *S. borealis* were captured in July. One immature male *S. borealis* was captured on 11 August in a stand of spruce and fir in which every canopy tree was dead from defoliation by Spruce Budworm. Other small mammals collected were *Microtus chrotorrhinus* (Yellow-nosed Vole) (2), *M. pennsylvanicus* (4), *Clethrionomys gapperi* (46), *Peromyscus maniculatus* (6), and *Sorex cinereus* (17).

During our investigations of U.S. records of *S. borealis* we learned of a museum specimen that was apparently misidentified (T. French, personal communication). G. C. C. borrowed this specimen of skin and skull (Number 2748) from the Montshire Museum of Science, Hanover, New Hampshire, and compared it with other *S. borealis* specimens. It was obviously another *S. borealis*. This adult female had been collected on 11 October 1958 by T. Peterson on Mt. Moosilauke, Grafton County, New Hampshire, at an elevation of 1160 m.

There are now seven recorded specimens of *S. borealis* from four locations in Maine and New Hampshire. The reasons for the rarity of this species are not clear. Two possible hypotheses are 1) that their required habitat is scarce, and 2) that they cannot coexist with closely related small mammals. Neither hypothesis is supported by our observations. The Northern Bog Lemming is not restricted to scarce alpine tundra habitat in the northeast but is known to live at elevations from 400 m to 1375 m, and in habitats including alpine sedge meadow, Krummholz, spruce-fir forest with dense herbaceous and mossy understory, and in wet meadow and mossy stream-sides (Preble 1898). They have been found to occur in rich assemblages of small mammal species including two and three other microtine rodents. In the Caribou Springs locations they have been found after an interval of 83 years.

Elsewhere in the U.S., the species is recorded from Minnesota, Montana, Idaho, and Washington. In all these states, however, it occurs only in the northern portions and is described as “elusive”, “rare and local”, or occurring in “small, semi-isolated or isolated pockets” (Wright 1950; G. Nordquist, personal communication; D. Genter, personal communication). The species is also known from a variety of habitats and elevations in the northwest (Wilson et al. 1980). Even in Canada, which constitutes the primary range, *S. borealis* specimens, especially the eastern forms, are “among the rarest of mammals” in collections (Anderson and Rand 1943; Banfield 1974; Peterson 1966).

Further study of the distribution, ecology, and reproductive biology of this species would be helpful in the understanding of rarity, an important natural phenomenon.

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Literature Cited

- Anderson, R. M., and A. L. Rand. 1943. A new lemming mouse (*Synaptomys*) from Manitoba with notes on some other forms. *Canadian Field-Naturalist* 57: 101-103.
- Banfield, A. W. F. 1974. *The mammals of Canada*. University of Toronto Press. Toronto, Ontario. 438 pp.
- Clough, G. C. 1987. Relations of small mammals to forest management in northern Maine. *Canadian Field-Naturalist* 101: 40-48.
- Dutcher, B. H. 1903. Mammals of Mt. Katahdin, Maine. *Proceedings of the Biological Society of Washington* 14: 63-72.
- Hall, E. R., and K. Kelson. 1981. *The mammals of North America*. Two Volumes. The Ronald Press, New York. 1083 pp.
- Howell, A. B. 1927. Revision of the American lemming mice (Genus *Synaptomys*). Bureau of Biological Survey. *North American Fauna* 50: 1-38.
- Peterson, R. L. 1966. *The mammals of eastern Canada*. Oxford University Press, Toronto, Ontario. 465 pp.
- Preble, E. A. 1899. Description of a new lemming mouse from the White Mountains, New Hampshire. *Proceedings of the Biological Society of Washington* 13: 43-45.
- Wilson, C., R. E. Johnson, and J. D. Reichel. 1980. New records for the northern bog lemming in Washington. *The Murrelet* 61: 104-106.
- Wright, P. L. 1950. *Synaptomys borealis* from Glacier National Park, Montana. *Journal of Mammalogy* 31: 460.

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A Key to the Identification of Some Small Boreal Mammals of Central Canada from Guard Hairs

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Thompson, I. D., Mark S. Porter, and Sherry L. Walker. 1987. A key to the identification of some small boreal mammals of central Canada from guard hairs. *Canadian Field-Naturalist* 101 (4): 614–616.

A key to the identification of common mammalian diet-items of Marten, *Martes americana*, from north-central Ontario is presented. Guard hairs from scats or stomach contents are used to identify 17 species of rodents, insectivores, mustelids and hare. Although developed for Marten in Ontario, the key will be of value to food studies of all small carnivores from boreal regions of central eastern Canada.

Key Words: Marten, *Martes americana*, Soricidae, Sciuridae, Cricetidae, Zapodidae, Leporidae, small mammals, hair identification, Ontario.

Few keys are available to identify remains of small boreal mammals of eastern or central Canada from the stomach contents or scats of predators. Diet choice of Marten, *Martes americana*, was studied as part of a five-year research program into the effects of timber-harvesting on this predator and its small mammal prey. Use of published keys, including Moore et al. (1974), Day (1966), Adjoran and Kolenosky (1969), and Mayer (1952), led to some misidentifications and confusion because of the necessity of using several keys at once. As a result, we developed our own key by integrating the existing keys with descriptions of a collection of reference hairs from our study area.

Methods

The study area was located about 40 km north of Manitouwadge, Ontario (49°15'N, 85°35'W), in an area classified by Rowe (1972) as Boreal Forest-Central Plateau. The study was conducted from fall 1980 until winter 1985.

Mammalian hair is of two types: guard hairs and underfur. The latter is finer and shorter than guard hair and tends to be less pigmented. Guard hairs are longer, wider and more pigmented, and were used in our identifications.

Terminology follows Moore et al. (1974) and for details the reader should refer to that paper. Terms used are summarized as follows: shaft refers to the entire length of the hair; shield is a widened section of the shaft at the distal end; stricture refers to an obviously constricted section of the shaft; medulla is the centre internal area of a hair which must be viewed at high magnification (usually 200–400x); medullary configuration is a description of the appearance of the medulla; and colour bands refer to different coloured sections of the shaft.

Descriptions of medullary configuration used in this key include multiserial ladder — columns of round or rectangular cells; cellular — similar to multiserial but with only one or two columns of cells; lattice — many fine, thin-walled cells arranged without pattern; unbroken — continuous tube with irregular cells; with cortical intrusions — “islands” suspended in the medulla; and coiled — a spiral appearance. Hairs were often opaque and the structure of the medulla could not be seen. In these cases we located other, more transparent hairs. Cross-sections were classified as oval, oblong, or with concavities.

Small mammals on the study area were trapped in snap traps and hair samples removed for analysis. For hairs of each species, the following variables were recorded: colour, colour-banding, shaft strictures, length, maximum width, configuration of the medulla, and shape of the cross-sections of all regions of the shaft. Measurements of length and width were taken on hairs from the dorsal and lateral regions of several adult animals for each species. Width was measured in microns using a scaled ocular on a high-powered microscope, and length was determined with a ruler under a dissection microscope. Enough hairs (generally more than 20) were measured to obtain an estimate of mean length with a standard deviation equal to less than 10% of the mean for each species. Interspecific comparisons were performed by t-tests with a rejection level set at $P \leq 0.01$ (Sokal and Rohlf 1981).

Various methods have been described for cross-sectioning hair (Day 1966; Korschgen 1980). The method which we found to be most satisfactory was to place a few drops of melted paraffin wax on a glass slide and allow it to cool just to the point where the surface was congealed. Several hairs were then placed

parallel to each other on the surface using tweezers, and covered with more paraffin. The wax was then allowed to cool completely and cross-sections about 1 mm wide were cut with a scalpel. These were examined under a high-powered microscope.

Results

Small mammal species not found on our study area and so not included in the key were Pygmy Shrew (*Sorex hoyi*), Smoky Shrew (*Sorex fumeus*), and Star-nosed Vole (*Condylura cristata*). Two other uncommon shrews, Northern Water Shrew (*S. palustris*) and Arctic Shrew (*S. arcticus*), were also excluded. None of these species, with the possible exception of the Smoky Shrew, are very common in central boreal areas and so their exclusion does not particularly diminish the value of our key in terms of its general utility. The key was derived primarily for small rodents and insectivores. However, Varying Hare (*Lepus americanus*), Red Squirrel

(*Tamiasciurus hudsonicus*), and Northern Flying Squirrel (*Glaucomys sabrinus*) were also included because these are common foods of Marten and other boreal carnivores (Banfield 1974). Marten hair occurred in most scats, and hairs of Short-tailed Weasels (*Mustela erminea*) and Least Weasels (*M. nivalis*) were also found in some samples. Therefore, these three mustelids were included in our key.

We were unable to distinguish between the two *Microtus* species in the area, Meadow Vole (*M. pennsylvanicus*) and Yellownose Vole (*M. chrotorrhinus*), nor could we separate Southern Bog Lemming (*Synaptomys cooperi*) from Heather Vole (*Phenacomys intermedius*). It is possible to distinguish between the latter two species by the grooved upper incisors of the Southern Bog Lemming (Banfield 1974). In most cases, incisors were available in the sample and so this was not a major problem. Hair from the two weasel species in this key may be distinguished in winter by the white hairs of the Short-

A key to small boreal mammals of central Canada from guard hairs

- 1a. Distinct and numerous strictures present 2
- 1b. No or at most one stricture present 3
- 2a. Hairs less than 6 mm in length *Sorex cinereus*
- 2b. Hairs greater than 6 mm in length *Blarina brevicauda*
- 3a. Hair with triple colour band (red/black/red) *Tamiasciurus hudsonicus*
- 3b. Hair uniform in colour or at most one band 4
- 4a. Length greater than 18 mm 5
- 4b. Length less than 18 mm 6
- 5a. Medullary configuration multiserial ladder *Lepus americanus*
- 5b. Medullary configuration unbroken with cortical intrusions, colour dark brown *Martes americana*
- 6a. Medullary configuration lattice or unbroken cellular in the shield region, length less than 11.5 mm, oval cross-section *Mustela erminea* or *M. nivalis*
- 6b. Medullary configuration unbroken with cortical intrusions 7
- 7a. Hairs with single colour band 8
- 7b. Hairs uniformly dark (often appear grey or black) 10
- 8a. Dark coloured tip greater than 2 mm, red band greater than 3 mm, shield diameter more than 65 μ *Tamias striatus*
- 8b. Dark coloured tip greater than 2 mm, red band greater than 3 mm, shield diameter less than 65 μ 9
- 9a. Length greater than 13 mm, and obvious spatulate tip *Eutamias minimus*
- 9b. Length greater than 13 mm with no spatulate tip *Glaucomys sabrinus*
- 10a. Diameter of shield less than 36 μ *Peromyscus maniculatus*
- 10b. Diameter of shield greater than 36 μ 11
- 11a. Cross-section through distal region shows 3 or 4 concavities, and through proximal region shows 1 or 2 concavities 12
- 11b. Cross-section through distal region shows 2, 1 or 0 concavities 13
- 12a. Diameter of shield less than 55 μ , some may show dark red tips *Clethrionomys gapperi*
- 12b. Diameter of shield greater than 55 μ *Synaptomys cooperi* or *Phenacomys intermedius*
- 13a. Cross-sections in all regions show no concavities 14
- 13b. Cross-sections in all regions show 1 or 2 concavities *Microtus* spp.
- 14a. Medulla tightly coiled, hairs greater than 10 mm long, and may be greater than 80 μ wide *Zapus hudsonius*
- 14b. Medulla loosely coiled, hair less than 10 mm long, always less than 80 μ wide *Napaeozapus insignis*

tailed Weasel and pigmented hairs of the Least Weasel.

Discussion

The key was successful in all trials using samples of known species tested on two observers who were unaware of the correct identification, and we therefore believe that the key is accurate. This key is nearly comprehensive for prey species of small carnivores in boreal forests of central and eastern Canada. Using the techniques outlined here, other species could be added if needed for a particular study.

Limitations of the key must be recognized by the user. It is possible that rare species or hairs from non-prey species may be found. For example, many small carnivores scavenge and hair of boreal ungulates, such as Moose (*Alces alces*), could therefore be encountered. In those cases the manual of Adjoran and Kolenosky (1969) would be useful to aid in identification. However, the latter work is of limited value for small forest rodents or shrews, having been primarily developed for large mammals.

Measurements of length and width should always be made on at least 10 guard hairs. Care should be taken to search a sample thoroughly for different species; we often found two to three species in a given scat. Once the observer is familiar with the key and the necessary techniques, identification of a hair may be made in less than half an hour.

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Literature Cited

- Adjoran, A. S., and G. B. Kolenosky. 1969. A manual for the identification of hairs of selected Ontario mammals. Ontario Ministry of Natural Resources Research Report (Wildlife) 90. 64 pp.
- Banfield, A. W. F. 1974. The Mammals of Canada. University of Toronto Press, Toronto. 438 pp.
- Day, M. G. 1966. Identification of hair and feather remains in the gut and faeces of stoats and weasels. *Journal of Zoology* 148: 201-217.
- Korschgen, L. J. 1980. Procedures for food habits analyses. Pages 113-137 in *Wildlife investigational techniques*. Edited by S. D. Schemnitz. The Wildlife Society, Washington. 686 pp.
- Mayer, W. V. 1952. The hair of California mammals with keys to the dorsal guard of California mammals. *American Midland Naturalist* 48: 480-512.
- Moore, T. D., L. E. Spence, and C. E. Dugnolle. 1974. Identification of the dorsal guard hairs of some mammals of Wyoming. Wyoming Game and Fish Department Bulletin Number 14. 164 pp.
- Rowe, J. S. 1972. The forest regions of Canada. Canadian Forestry Service Publication Number 1300. 172 pp.
- Sokal, R. R., and F. J. Rohlf. 1981. *Biometry*. W. H. Freeman and Company, San Francisco. 859 pp.

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News and Comment

New Honorary Members and the 1986 Ottawa Field-Naturalists' Club Awards

At the 1987 Soirée two Honorary Memberships and the four Club awards (Member of the Year, Service, Conservation and Anne Hanes Natural History Award) were presented. In addition to reading the citations and presenting the award certificates to their recipients, President W. K. Gummer selected Barbara Martin to receive The President's Prize. In addition, the Anne Hanes Natural History Award winner was given a beautiful wood bird carving crafted by E. Dickson of Ottawa.

HONORARY MEMBERS

Donald E. McAllister

The OFNC is pleased to confer Honorary Membership on Dr. Donald E. McAllister in recognition of his contributions to general and scientific knowledge of Canadian fishes. His studies have involved both fresh and salt water, including Atlantic and Pacific coasts, and arctic marine waters. He has published over 100 papers on taxonomy, biogeography and fossils, and on methods of collecting and preserving specimens, as well as many valuable reviews. He is acknowledged as the expert on fishes of North American arctic waters, and has a monograph in preparation on this subject. For Club members, his most familiar publication is likely *Fishes of Canada's National Capital Region*, co-authored with Brian W. Coad. Selections from this appeared in *Trail & Landscape* in 1975 and 1976.

Dr. McAllister has recorded species new to Canada, and also has described some new to science including species from Easter and Riapa Iti Islands. He has contributed to the *Atlas of North American Fresh Water Fishes*. His broad interests extend into the past, with contributions on post-glacial fossils in the Greens Creek clays, and more recent fish remains in archeological sites. He is an active participant on the Committee on the Status of Endangered Wildlife in Canada. His strong conservation interests are evident as well in his commitment as a director of the International Marine Alliance; his participation and personal support in efforts to retrain Phillipine fishermen in the use of nets instead of cyanide for the collection of reef species for the aquarium trade may save an entire ecosystem from disaster.

A recent major and pioneering contribution is in the field of computerization of collection and research

data for museum use. He is currently compiling a computerized list of fishes of the world; this working list now contains over 20 000 species.

In addition to his curatorial and research output, his influence is evident through university lectures and supervision of graduate students at both Ottawa and Carleton Universities, and on scientists and post-doctoral fellows visiting the museum. His knowledge and great capacity for work are inspirational, and he is a ready source of information to all.

Dr. McAllister was born in Victoria, British Columbia, obtaining undergraduate and graduate training at the University of British Columbia with a year at the University of Michigan during his Ph.D. studies. Following curatorial experience at both schools, he joined the National Museum of Natural Sciences in 1958 as Curator of Fishes, a position he held for 28 years until relinquishing responsibility for the collections to Dr. Brian Coad. Don can now devote his full time to being Research Curator in Ichthyology and is still at least one decade from retirement. While under his direction the National fish collection grew from less than 5000 to more than a million specimens, becoming a world-class reference. He joined our Club in 1958, and has been an Associate Editor of *The Canadian Field-Naturalist* 1965-72 and 1982 to the present. He is also an Associate Editor of the *Canadian Journal of Zoology*.

Robert W. Nero

Bob Nero is widely recognized as one of the premier field naturalists in Canada. Since moving to western Canada from the northern United States in 1955, Nero has been a key participant in the issues and efforts of naturalists and naturalist organizations in western Canada. First in Saskatchewan and then in Manitoba, Bob Nero has applied his time, expertise and patience to his passionate interest in the natural world. Although an ornithologist by training (completing a Ph.D. in wildlife management and zoology at the University of Wisconsin on the ecology of Red-winged Blackbirds), Nero's interests are very broad. He has written many articles on mammals, birds, reptiles and amphibians, insects and even archaeology. He is perhaps best known his critically-acclaimed book *The Great Gray Owl: Phantom of the Northern Forest*. His studies of this rare and

interesting animal on which he is the North American authority continue, as do his efforts to encourage its protection. Bob Nero and his captive Great Gray Owl are well-known and warmly-received visitors in schools all across southern Manitoba.

In recent years Nero has written two other books. He co-authored a book on the Cougar in Manitoba with Robert Wrigley in 1982. This study of the history of that provincially rare and endangered species was well received. Following the success of the Great Gray Owl book, the Smithsonian Institution Press urged him to write up his studies of the Red-winged Blackbird and *Red-wing* appeared in 1984.

In addition to the important contributions that have resulted from his personal interests, Bob Nero has assisted the search for and documentation of biological information through a number of professional positions. He has served as assistant director at the Saskatchewan Museum of Natural History, an associate professor of biology at the University of Saskatchewan (Regina Campus), chief of natural history at the Manitoba Museum of Man and Nature and, currently, as wildlife specialist with the Manitoba Department of Natural Resources. Nero has been a member of the Ottawa Field-Naturalists' Club since 1961.

The fine mix of a personable and generous character and professional competence have resulted in direct and indirect contributions to our knowledge of and appreciation for the natural world in Canada that are most significant. We will reap the benefits of Bob Nero's labours for generations to come.

MEMBER OF THE YEAR

Roy John

This year's Member of the Year Award is presented to Roy John. As chairman of the Bird Records Subcommittee, he has played a strong role at a critical time, directing this committee to meet Club goals of promoting appreciation of nature, of encouraging investigation, and of publishing information. This all refers to the special birding activity of evaluating and properly recording unusual bird sightings and breeding records. Concise Terms of Reference for the Subcommittee were drawn up, and have been approved by Council. The Club is grateful to Roy for his accomplishments in what the Birds Committee Annual Report referred to as "a year of self examination". The outcome of this process is a success.

ANN HANES NATURAL HISTORY AWARD

Clarence Frankton

When someone reaches 80 years of age it is reasonable to expect that their level of activity will lessen. This is particularly the case in regards to

tramping through fields, thickets, woodlands and all the other places naturalists go to pursue their interest. That message seems not to have gotten through to this year's Anne Hanes Natural History Award winner, Clarence (Clarrie) Frankton. After he retired in 1970 Clarrie applied his not inconsiderable energies to learning even more about natural history in general and floristics in particular in the Ottawa District. While his interests took him to many places, the Stony Swamp always held a special fascination. Over the years he and his wife Enid — his constant field companion and associate — have looked under virtually every stone in that area. Largely as a result of their efforts, a 1982 inventory of the Stony Swamp was able to report over 630 species of plants. While that established a new record total for any one area in the District, Clarrie was not content to leave it at that. He has continued to add to this total and to that end, 1986 was most successful. Another 5 or 10 ten species were found this year, including at least one that is new to the District, bringing Clarrie's total to something near 690 species. Even the legendary John Macoun wasn't able to do that!

In addition to his impressive botanical contributions, Clarrie remains an active observer of bird life, both in the Stony Swamp and at Britannia. The regular observations of Clarrie and Enid along the Ottawa River yielded valuable information for the 1986 Christmas Bird Count in this part of the city.

All in all, the effort and achievement demonstrated by Clarrie Frankton in 1986 should be inspirational to every field naturalist in the Ottawa Valley, regardless of their particular area or areas of interest.

CONSERVATION AWARD

Jane Topping

Since the day in 1978 when she encountered a stranger on her property near Brockville and learned of the impending Glen Elbe drain that would seriously affect wetlands there, Jane Topping has worked for the preservation of wetlands. She soon realized that the local drain was only a symptom of a far more widespread disease and that in order to achieve anything worthwhile the problem had to be attacked in its totality.

Since 1978 Jane has lobbied people at many levels of government and in many walks of life. Through her personal mixture of knowledge acquired through hard work and patient research, an effective "underground" information network to what is going on in government departments, and plain old fashioned stubbornness, she has had an important impact in this critical conservation issue.

Jane has done much for wetlands by drawing governments' attention to the inequities (and

iniquities) of the Ontario Drainage Act. This act offers large subsidies to landowners to encourage the drainage of land for agricultural purposes — regardless of the wider ecological and environmental consequences. Her report to Environment Canada on how to increase public awareness and her persistence in getting it read and acted upon, was an important early encouragement of that department's involvement in wetlands. Her submission on behalf of the Ottawa Field-Naturalists' Club to the Inquiry on Federal Water Policy broadened the Commission's thinking from strictly that of rivers and lakes to that of wetlands in general, with the result that wetlands concerns were addressed in the final report.

Jane continues her active involvement in this and other issues as a member of the OFNC's Conservation Committee. What began as a private concern for personal property rights has broadened into a wide-ranging effort on behalf of us all. And the Glen Elbe Drain that started it all . . . ? Jane hasn't stopped it (yet) but it's been stalled for over six years. And don't be surprised to hear one day that Jane's persistence has resulted in the permanent solution to this problem.

SERVICE AWARD

Dorothy Greene, Marc Guertin, Lisa Meyboom, Jim Montgomery and Harry Thomson

While much is being said — and rightly so — of the tremendous achievement that 20 volumes of *Trail & Landscape* represents, few of us have any real idea of just how much work and commitment goes into the production of this outstanding publication. While we can see the names of authors and editors fairly prominently displayed on the pages of the piece, have you ever thought about how it gets to your door? Or who makes sure that the spelling is correct? Or who prepares the illustrations and lay-out?

The 20th anniversary of *Trail & Landscape* seems a most appropriate time to offer thanks to some of those most directly involved individuals in this behind-the-scenes effort. We should add that many others are involved — typists, mailers, etc.) but several people can be identified as most directly carrying the production load for these past two decades. Accordingly, the OFNC is pleased to give the 1986 Service Award to the following:

Dorothy Greene (Typing Co-ordinator)

Marc Guertin (Graphics)

Lisa Meyboom (Mailing)

Jim Montgomery (Business Manager)

Harry Thomson (Business Manager; proofing)

In honouring these contributors we mustn't forget another who has performed in virtually all of these capacities and continues to be very active in the production duties of *Trail & Landscape*. Joyce Reddoch, the present editor of *Trail & Landscape*,

could certainly share the stage with these five. You may recall that Joyce was awarded the 1981 Member of the Year Award in part for her important production work on behalf of *Trail & Landscape* to that point. Similarly, we honoured Eileen Evans with the 1985 Service Award for her fine efforts on the Club's behalf, including her important contribution as a proof reading co-ordinator for *Trail & Landscape*.

DANIEL F. BRUNTON

Chairman, Awards Committee

and the members of the Ottawa Field-Naturalists Awards Committee.

THE 1986 PRESIDENT'S PRIZE

Barbara Martin

The 1986 President's Prize goes to a member who, along with other Club duties, took on additional responsibility enabling the Club to make a rather major change in conduct with minimal difficulty.

It had become apparent some time ago that the Club would require new arrangements for use of computer equipment for certain operating records, and after study of alternatives, equipment was bought in early 1986. Barbara Martin was much involved in the planning for computer self-sufficiency. She was fully aware of club needs, and helped select the language for computer use. When other plans fell through and a temporary home for the computer was urgent, Barbara offered space in her home. Since then (nearly a year) the computer, the printer, the paper and other supplies have occupied the place of honour in the centre of her dining room. She was appointed head programmer. She ensured that interested Councillors and others could see and try out the computer. She arranged for operating supplies, and for suitable service contracts. In short order the Club's membership list (nearly 1200 memberships of all kinds) had been entered, and mailing labels for *Trail & Landscape* were ready on schedule. Furthermore, she laid down a program for the next year giving subject and schedule requirements, and had begun to prepare us for additional applications.

The equipment had been expected to leave her home in April but once again expectations were not met and new plans are needed. Fortunately, Barbara remains actively in a position to offer advice and to assist, as a member of the new Computer Management Committee.

I take real pleasure in presenting a book, *The Art of Robert Bateman*, to Barbara Martin for her strong and effective efforts to introduce us properly to our new equipment, for housing it and making it available to others, for ensuring its proper use, and finally for her success in all this.

BILL GUMMER

President, Ottawa
Field-Naturalists' Club

Garrett C. Clough, 1932-1987

Garrett C. Clough (*see* Occurrence of the Northern Bog Lemming, *Synaptomys borealis*, in the northeastern United States, pp. 611-613) died in the Veterans Hospital at Togus, Maine, 22 May 1987, at age 55. Garrett was born in Mystic, Connecticut, to Francis and Gladys Bush Clough. He graduated from Union College, Schenectady New York, received his MSc. from University of Michigan at Ann Arbor and his Ph.D. from University of Wisconsin at Madison. He taught at Dalhousie University, Halifax, Nova Scotia, the University of Rhode Island and Nasson College, Springvale, served as a biology consultant for the state of Maine and spent four years in Norway. A teaching and research assignment in Kenya was cut short in January 1987 by the diagnosis of cancer.

I met Garrett once, 24 June 1986, shortly before he left for Kenya. When in Ottawa he stopped at the

Museum for an update on his submitted manuscripts and over coffee we shared our mutual convictions on the importance of *The Canadian Field-Naturalist* in the publication of both research and observations on natural history of Canada and the northern United States. Though our acquaintance was brief, I can appreciate the extent of premature loss to natural history which his friends have felt.

My thanks to two of these, John Albright and to Ralph S. Palmer. The latter kindly sent the notice which appeared in the *Maine Sunday Telegraph* 24 May 1987, page 29A, from which details of Garrett's career have been drawn.

FRANCIS R. COOK
Editor

Society of Canadian Ornithologists — Membership Invitation

The Society of Canadian Ornithologists (SCO) was formed in 1982, in conjunction with the Canadian hosting of the XIX International Ornithological Congress in Ottawa in June 1986. Since its inception our membership has grown to over 150 members and the Society now publishes *Picoides*, the Bulletin of the SCO, twice a year.

The objectives of the SCO are to promote ornithology in Canada, whether it is enjoyed by

amateurs or professionals, and to provide a common voice and information exchange for persons interested in birds.

Please give your support to this organization by taking out a membership. Send your remittance (\$10.00) to:

PHILIP STEPNEY
Provincial Museum of Alberta, 12845-102 Avenue,
Edmonton, Alberta T5N 0M6.

Canadian Society of Environmental Biologists

The Ontario Chapter of the Canadian Society of Environmental Biologists met in October, 1987. A slate of officers was elected and plans are being formulated for a variety of activities. Meetings are planned at regular intervals during 1988.

Objectives of the CSEB include the following: to further conservation of the natural resources of Canada and prudent management so as to minimize adverse environmental effects, and to develop and promote policies that seek to achieve a balance among

resource management and utilization, protection of the environment and the quality of life.

Individuals with training in biological sciences are invited to join the Society. Membership applications can be obtained by writing to: Canadian Society of Environmental Biologists, P.O. Box 962, Station F, Toronto, Ontario, M4Y 2N9.

KEN DANCE
Membership Chairman
CSEB, Ontario Chapter

Canadian Ornithologists Honour W. Earl Godfrey

The Society of Canadian Ornithologists was proud to present in 1986 the first DORIS HEUISTIS SPEIRS AWARD FOR CONTRIBUTIONS TO CANADIAN ORNITHOLOGY to W. Earl Godfrey, retired Curator of Birds, National Museum of Natural Sciences, and author of *The Birds of Canada*. This

award, given in honour of significant contributions to Canadian ornithology, is open to anyone making a contribution either technical or popular in nature.

Earl was born in Wolfville, Nova Scotia, and very early began a career in ornithology, first as a summer student with the National Museum of Canada, then as

a Research Associate with the Cleveland Museum of Natural History. He went on to serve as Curator of Birds at the National Museum of Canada from 1947 until retirement in 1976, from the position of Chief of the Division of Vertebrate Zoology. Earl is the author of *The Birds of Canada*, published in 1966, and he completely revised the 1986 edition, bringing to over 200 the number of titles he has published. Equally important, during his distinguished career, Earl has worked tirelessly encouraging interest in birds among younger people across Canada. Many amateur and professional ornithologists have known Earl as a

friend and a field companion, as well as a helpful and knowledgeable advisor. The development of ornithology in Canada owes a debt of gratitude to Earl Godfrey.

PHILIP H. R. STEPNEY

Recording Secretary, Society of Canadian Ornithologists, Provincial Museum of Alberta, 12845-102 Avenue, Edmonton, Alberta T5N 0M6

Editor's note: W. Earl Godfrey is an honorary member of the Ottawa Field-Naturalist Club.

Canadian Entomologists Honour Eugene G. Munroe

Dr. Eugene Munroe was honoured in 1987 by his peers by being made an Honorary Member of the Entomological Society of Canada. This distinction is reserved for a small number of entomologists who are deemed by their colleagues to have made significant contributions, not only to the science of Entomology, but for their leading roles in Society activities and liaison with the public. Although the Society has over 800 members, there are only eight Honorary Members.

Eugene Munroe was born in Detroit, Michigan, and later moved to Canada with his family, and became a Canadian citizen in 1932. He carried with him a love of entomology from an early age, and his first entomological position was as a summer assistant at the Lyman Museum, then at McGill University. After a brief time in the Canadian Armed Forces during World War II, he resumed his career at Cornell University where he received his Ph.D. in 1948.

Dr. Munroe returned to Canada and, after teaching briefly at Macdonald College, was hired by Agriculture Canada, where he joined the Systematic Entomology Unit in Ottawa in 1950. From that time until his retirement in 1979, he established an international reputation and was recognized as a world authority on the systematics and distribution of the moths and butterflies. He has conducted many collecting trips throughout North America, Central

and South America, the West Indies, Europe, East, West and South Africa, Thailand, Sarawak, Sabah, New Guinea, and Fiji. As a result of his efforts, he has assembled one of the leading collections of pyralid moths in the world. Dr. Munroe has published over 200 scientific papers during his career, many of which remain among the most important of their kind.

Eugene Munroe has been widely recognized for his outstanding efforts. He has received the Queen's Silver Jubilee Medal, he is a Fellow of the Royal Society of Canada, an Honorary Life Member of the Lepidopterist's Society and the Ottawa Field-Naturalists' Club, and a Socio de Honor of the Sociedad Hispano-Lasa-Americana de Lepidopterologia. He has been a visiting scientist at the British Museum (Natural History), the Leiden Museum, the Bishop Museum in Honolulu, the C.S.I.R.O. in Canberra, the Smithsonian Institute, and other institutions in the United States. He is a member of numerous professional societies and was previously honoured by the Entomological Society of Canada in 1982, when he was awarded the Gold Medal for outstanding achievement.

N. J. HOLLIDAY

Chairperson, Membership Committee

Department of Entomology, University of Manitoba, Winnipeg, Manitoba R3T 2N2

Conservationists Honour Claude E. Garton

Claude E. Garton of Thunder Bay, a conservationist, botanist and teacher who is a world authority on northern Ontario plants, was Ontario's conservationist of the month for November 1987.

The monthly award was presented by the Ministry of Natural Resources as part of Wildlife '87, a national conservation awareness program that celebrated the

100th anniversary of Canada's first wildlife sanctuary at Last Mountain Lake, Saskatchewan. These awards were instigated to publicize, encourage, and highlight individual effort in conservation and wildlife management.

As a young teacher, Mr. Garton began collecting, mounting and labelling vascular and non-vascular

plant specimens when he moved to northwestern Ontario in 1928. He soon became the supplier of specimens to herbariums across Canada and the major capitals of the world.

In 1967, Mr. Garton donated his personal herbarium to Lakehead University in Thunder Bay. The Claude E. Garton Herbarium today contains more than 90 000 specimens, 40 being botanic firsts for Ontario which were personally uncovered by Mr. Garton.

But his influence has ranged beyond the field of botany. In 1968, he worked with a team of students studying the effects of spruce budworm spray on birds and aquatic life. He also collected data on the Mattawin River in preparation for establishing a fish

and game reserve and was the first to discover the “bat cave” at Cavern Lake.

As a teacher — both professionally and on a voluntary basis with small groups — he has taught hundreds of students about everything from wildlife and fisheries to Indian pictographs and rock polishing.

KELLY LUCAS

Wildlife Branch, Ministry of Natural Resources, Toronto, Ontario

STEVE TOOLE

Regional Fish and Wildlife, Ministry of Natural Resources, Thunder Bay, Ontario

Editors Note: Claude Garton is an Honorary Member of the Ottawa Field-Naturalists Club.

1987 Chevron Conservation Award to Ernie Kuyt

Ernie Kuyt of Edmonton, Alberta, received a 1987 Chevron Conservation Award for his work in the study and protection of the endangered North American Whooping Crane. Generally working alone in remote areas, often under adverse conditions, he has contributed, according to his peers, more than any other individual to the protection of the great bird.

A wildlife biologist for the Canadian Wildlife Service, he has monitored the breeding grounds and radio-tracked the crane’s migratory flights across international boundaries from Alberta to Texas. He is credited with the discovery of the habitat of the crane population’s non-breeding segment, as well as uncovering numerous facts about breeding and the birds’ summer habitat.

In 1987 Chevron Conservation Awards went to 20 citizen volunteer and professional conservationists and five non-profit organizations from 16 states, the District of Columbia, and Canada. Each received

\$1000 and a bronze plaque at the Awards ceremony at the Four Seasons Hotel in Washington, D.C., 14 May.

Founded 33 years ago, first sponsored by American Motors, then Gulf Oil, and now by Cheron, the Awards Program was the idea of Ed Zern, a nationally prominent outdoor writer, editor-at-large and columnist for *Field and Stream* magazine and still, at 76, director of the program, to give recognition to those relatively unknown people who work to protect the environment. The program honors both individuals and organizations who have thus selflessly devoted themselves to the conservation of natural resources.

BILLROPER

Corporate Program Director

DAVID WENTLEY

Ketchum Public Relations

Chevron Conservation Awards, P.O. Box 7753, San Francisco, California 94120-7753

Wildlife Habitat Reclamation Manual

A methods manual for reclamation of wildlife habitat has been prepared by The Delta Environmental Management Group Ltd., Calgary.

This manual describes concepts and techniques applicable to major biomes in the Canadian prairie provinces. Included are the Mountains and Foothills, Boreal Forest, Aspen Parkland, and Prairie Grasslands.

Reclamation goals in western Canada traditionally adopted either forestry or agriculture as end uses for reclaimed lands depending on the particular location and landform. However, with improved reclamation

methods and an increased awareness of the value of natural areas, greater emphasis has been placed on reclamation and enhancement of wildlife habitat.

This manual is a summary of knowledge gleaned from industrial operators involved in land reclamation programs and scientific literature dealing with wildlife habitat management. It provides concepts and direction on reclamation plans and includes timing and resource considerations. Details for modifying landforms, developing water bodies and establishing plant communities suitable for key wildlife species are included.

Copies are available from: Communications Branch, Environment Canada, Western and Northern Region, Twin Atria 2, 2nd Floor, 4999 - 98 Avenue, Edmonton, Alberta T6B 2X3.

GARRY TROTTIER
Canadian Wildlife Service, Environment Canada, Edmonton, Alberta

BARRY MUNSON
Conservation and Protection, Environment Canada, Edmonton, Alberta

Prairie Endangered Species Workshop Proceedings

One-third of all the rare, threatened, and endangered species in Canada were once regular inhabitants of the prairie grasslands. Ploughing of native prairie for agriculture has virtually eliminated the grassland habitat on which these species depend. With this background, a three-day workshop was held at the Provincial Museum of Alberta, Edmonton, in January 1986 by the Federation of Alberta Naturalists. During the 32 sessions, 90 speakers from 30 organizations discussed the conservation and management needs of endangered prairie habitats and wildlife.

The Proceedings include 83 papers on endangered habitats and most threatened and endangered wildlife in the three prairie provinces. The papers on habitat confirmed that over 75% of all prairie habitats have been ploughed, grazed or urbanized. Over 95% of mixed grass prairie has been irreparably disturbed.

The papers on individual species discussed the status of each species, its current management, the need for a recovery plan, and future conservation needs. A number of low profile species such as the Bull Trout, Leopard Frog, and a variety of insects and plants were included in an effort to stimulate more conservation activity.

Holroyd, G. L., W. B. McGillivray, P. H. R. Stepney, D. M. Ealey, G. C. Trottier, and K. E. Eberhart. 1987. Proceedings of the Workshop on Endangered Species in the Prairie Provinces. Provincial Museum of Alberta Occasional Paper No. 9, 367 pp.

To order copies of the proceedings send \$10 per copy to Edmonton Natural History Club, Box 1582, Edmonton, Alberta T3J 2N9.

GEOFFREY L. HOLROYD
President, Edmonton Natural History Club, Box 1582, Edmonton, Alberta T6J 2N9

Annual Meeting: The Raptor Research Foundation

The Raptor Research Foundation, an organization whose purpose is to stimulate the dissemination of information concerning raptorial birds among interested persons worldwide and to promote a better public understanding and appreciation of the value of birds of prey, is holding its annual meeting on 26-29 October 1988, in St. Paul, Minnesota.

The regular meeting will be preceded, on Monday and Tuesday, the 24th and 25th, by a special international symposium on medicine, surgery, and diagnostic procedures relating to wild and captively held birds of prey. This symposium will be complementary to one held at Oxford University in

1980 out of which the proceedings *Recent Advances in the Study of Raptor Diseases* was published. A similar proceedings is planned for this meeting. Other organisers of this symposium include John Cooper MRCVS of the Royal College of Surgeons of England, Dr. David Remple of the Dubai Flacon Hospital, Dubai, United Arab Emirates, and Dr. Bruce Hunter of the CVM at Guelph, Ontario, Canada.

PATRICK T. REDIG
Meeting Chairperson
Raptor Research and Rehabilitation Program, c/o University of Minnesota College of Veterinary Medicine, 1988 Fitch Avenue, St. Paul, Minnesota 55108.

Proceedings of the International Association for Bear Research and Management

Copies of the 6th and 7th proceedings (1983 and 1986) of the International Association for Bear Research and Management (IBA) are now available. The 1983 proceedings are \$30.00 and the 1986 proceedings are \$35.00. Copies of earlier proceedings also are available: 1st proceedings (1968) \$5.00 4th

proceedings (1977) \$5.00 5th proceedings (1980) \$28.00. The 2nd and 3rd proceedings (1970 and 1974) are out of print.

These proceedings are a compilation of peer-reviewed papers published from the meetings of the International Association for Bear Research and

Management. Papers cover a wide variety of topics such as status and distribution, population biology, habitat relations, behavior and physiology, human-bear interactions, and management applications and deal with the seven bear species of the world.

Request for Beaver Folk-lore and Observations

As part of research on the life and activities of the Canadian Beaver, I would appreciate hearing from anyone who has any unusual or interesting experiences or stories to tell about this unique Canadian animal.

Although the Beaver was not declared Canada's national animal until 1975, it has played a significant

Send check payable to *IBA* to:

MICHAEL R. PELTON
Department Forestry, Wildlife, and Fisheries, Box 1071, The University of Tennessee, Knoxville, Tennessee 37901-1071

Purple Martin Colony Registry

The *Colony Registration Program* of the newly formed *Purple Martin Conservation Association* seeks the help of all persons in locating and registering Purple Martin colonies throughout all of North America in preparation for several projects designed to help this man-dependant species experiencing long-term declines within parts of its breeding range. If you know of someone who has a martin colony or is trying to attract one, or if you are interested in starting a colony yourself, please write to the P.M.C.A. You can

role in Canada's history, economy, environment and folk-lore for hundreds of years.

JIM CAMERON
P.O. Box 179, Kleinburg, Ontario L0J 1C0
Editors Note: Dr. James M. Cameron is Chairman of the Geography Department of Atkinson College, York University, 4700 Keele Street, North York, Ontario M3J 1P3

further assist by looking for martin houses or gourds in people's yards during your travels. If you locate some, please try to obtain the mailing addresses from either the street and house numbers, rural mailboxes, phone books or by stopping to ask and forward these addresses to us.

JAMES R. HILL
The Purple Martin Conservation Association, P.O. Box 178, Edinboro, Pennsylvania 16412.

Request for Information: Turkey Vulture Roosts.

As part of an ongoing, long-term research project on Turkey Vulture (*Cathartes aura*) feeding ecology I would like to locate as many active Turkey Vulture roosts from across Ontario as possible. I am particularly interested in monitoring the expansion of the species in the province, habitat selection, and diet. If you know the location of any vulture roots and would be willing to direct me to them you can contact

me at the address given below. Any assistance will be fully acknowledged and all information will be kept confidential.

KENT A. PRIOR
Department of Biology, Carleton University, Ottawa, Ontario K1S 5B6
Phone: (613) 564-2671 or 564-3867

New Periodical: *Sea Wind*

Bulletin of the International Marine Life Alliance, Edited by Don McAllister, IMA Canada, Ottawa. Quarterly. \$20/annum membership.

January - March, 1987, marked the initial publication of *Sea Wind* as the new quarterly bulletin of the IMA. This society is dedicated to research, education, and training towards the goal of harmony between humans and the sea. The aims are conservation and

wise use of marine resources, especially those on which third world countries depend. *Sea Wind* provides short articles and letters on marine resource management, environmental problems, and IMA projects. This is an essential area of research which

many *Canadian Field-Naturalist* readers will find interesting, and all should support. We wish this new bulletin every success.

Sea Wind is edited by Dr. Don McAllister of the National Museum of Natural Sciences in Ottawa, who

is also co-founder of IMA Canada and would be interested in contacts from prospective members.

E. WILSON EEDY
Book-Review Editor

Second International Conference of Leech Scientists

Hosted by the National Museum of Natural Sciences, Canada, the 2nd International Conference of Leech Scientists will be held in Ottawa, Ontario, 23-25 June, 1988. This conference addresses the theme "Leeches — Pest or Cure".

The Scientific Program will include plenary lectures, symposia, poster presentations and workshops. The program will be divided into the following sections Parasitology; Ecology; Medicine; Neurophysiology; and Taxonomy.

Keynote Speakers are: E. M. Bureson (Virginia),

R. W. Davies (Alberta), S. S. Desser (Ontario), J. G. Nichols (Switzerland), R. T. Sawyer (Wales) and J. Upton (Massachusetts).

Persons interested in the results of this Conference should so indicate by writing to:

ANNE STEVENSON
Registrar, International Conference of Leech Scientists,
Room 1, Victoria Memorial Museum Building, National
Museum of Natural Sciences, Post Office Box 3443, Station
D, Ottawa, Ontario K1P 6P4

Formation of Canadian Lower Vertebrate Societies

Two new Canadian professional societies have emerged recently. Both deal with lower vertebrates (reptiles, amphibians and fish) and have as their principal aims the diffusion of information and fellowship between Canadians interested in these organisms and the encouragement of further research within Canada.

The senior of the two, dealing with "higher" lower vertebrates (in a traditional hierarchical evolutionary sense, without prejudice to relative importance nor cladistic implications), is the Association of Canadian Herpetologists/Association Canadienne des Herpetologistes (CAH/ACH), which was informally created on 19 June 1986 in Victoria, British Columbia, by Canadians attending the American Society of Ichthyologists and Herpetologists Annual Meetings. At the next annual meeting of the ASIH in June 1987 at Albany, New York, the Canadian Association elected a President (Dr. David M. Green, Redpath Museum, McGill University, 859 Sherbrooke Street West, Montreal, Quebec H3A 2K6), a Secretary/Treasurer (Dr. Patrick T. Gregory, Department of Biology, University of Victoria, Victoria, British Columbia V8W 2Y2), and a Convenor for the next meeting to be held sometime during the combined American Society of Ichthyologists and Herpetologists/Herpetologists League/Society for the Study of Amphibians and Reptiles annual meetings 23-29 June 1988 at Ann Arbor, Michigan (R. Michael Rankin, Herpetology Section, National Museum of Natural Sciences, P.O. Box 3443, Station D, Ottawa, Ontario K1P 6P4).

Membership is \$1.00 per year on application to the Secretary/Treasurer with name, address, and research interests. The Association issues a "Bulletin" (newsletter), edited by Dr. Green. Three issues have appeared (March 1987: 3 pp.; September 1987: 9 pp.; March 1988: 8 pp.) packed with news from, and items of interest to, members.

A parallel cluster, focused on "lower" lower vertebrates and hatched immediately after the 1987 ASIH meetings, is the Canadian Association of ichthyologists/Association canadienne des ichtyologues (ACI/CAI). Dr. Alex Peden (Royal British Columbia Museum, Victoria, B.C.) is partly responsible for seeing the need for this group which also intends to meet to exchange informal views during the ASIH Ann Arbor meetings in June. The first issue of their Newsletter/Bulletin (31 pages) appeared in January 1988 and is edited by co-instigator Dr. Brian W. Coad, Ichthyology Section, National Museum of Natural Sciences, P.O. Box 3443, Station D, Ottawa, Ontario K1P 6P4. Requests for copies, and for inclusion on the ACI/CAI mailing list should be addressed to Dr. Coad. A \$2.00 contribution in cash or cheque payable to the "Fish Section Trust Fund" is requested to offset printing and mailing costs.

Both groups could be of particular value to students seeking information on the future of Canadian herpetology and ichthyology and on who is doing what and where, as well as providing a collective voice and pooled expertise on internal Canadian issues affecting these animals and their study.

FRANCIS R. COOK

Notice of Format Change in *The Canadian Field-Naturalist*

With Volume 102, Number 1, *The Canadian Field-Naturalist* will decrease in page size from the approximately 10 x 7½ inches used since 1970 (Volume 84) to approximately 9¾ x 6¾. This change will allow printing on a higher speed press at M.O.M. and thus keep publication costs down and avoid immediate increases in page charges to authors.

Reduced page margins will minimize loss in column width and allow a slight increase in their height in order to avoid loss in total text per page. The reduction will be greatest at the outer margin of the pages to maintain a maximum inner margin for ease of reading of both bound and unbound copies. A disadvantage is that in having issues bound, care in trimming must be specified: trimming can be

substantial — note that the Editor's Report for 1982 (*The Canadian Field-Naturalist* 96(2): 221 footnote to Table 1) gave page size since 1970 as 9¾ x 7¼ because it had been estimated from a bound volume.

This "modernization" is, inadvertently, a return to the traditional size of the journal throughout the 1918-1969 period, and to the text column widths of 1918-1957. Although we are losing the spacious margins brought in by Bob Hamilton in 1958 and the larger page size by Ted Mosquin in 1970 in eras of less costly printing, we will retain other improvements in style and format that they, and Lorraine Smith 1972-1981, evolved.

FRANCIS R. COOK
Editor

List of Original Descriptions Published in *The Canadian Field-Naturalist*: 1932–1986

DANIEL F. BRUNTON

Southwick Drive, R.R. 3, Manotick, Ontario K0A 2N0

Brunton, Daniel F. 1987. List of original descriptions published in *The Canadian Field-Naturalist*: 1932–1986. *Canadian Field-Naturalist* 101 (4): 627–635.

In 1931 A. LaRocque published a paper in the *Canadian Field-Naturalist* listing 415 original descriptions published in the journal and its predecessors since 1880. Original descriptions published subsequently, up to and including the 100th volume of *The Canadian Field-Naturalist/Ottawa Naturalist*, are listed here. Comparisons are drawn between the two half centuries of publication. In total, 733 original descriptions have appeared, with the greatest number being published in the 1900–1919 and 1940–1959 periods. Fewer descriptions have appeared since 1960, likely reflecting the fact that contemporary scientists prefer to publish taxonomic contributions (new taxa and combinations) in more specialized journals.

Key Words: *The Canadian Field-Naturalist*, *Ottawa Naturalist*, *Transactions of the Ottawa Field-Naturalists' Club*, original descriptions.

With the completion of 100 volumes of *The Canadian Field-Naturalist* and its predecessor, *The Ottawa Naturalist*, in 1986, the Ottawa Field-Naturalists' Club has yet another reason to be proud of its contribution to Canadian natural sciences. The most important purpose of these publications has been to document original field work and the resulting analysis of data. An important element has been the publication of new scientific names and original taxonomic descriptions for a wide variety of previously unrecognized flora and fauna — both recent and fossil.

A remarkably large number of original descriptions have appeared in the pages of *The Canadian Field-Naturalist* and its predecessors. In the early 1930s a list of the original descriptions that had appeared in *The Canadian Field-Naturalist*, the *Ottawa Naturalist* and the *Transactions of the Ottawa Field-Naturalists' Club* between 1880 and 1931 was published by A. LaRocque to "... facilitate the finding of descriptions of new species in the publication ... and ... to put before the members of the Club and the public concrete evidence of its service to Science in publishing work of the highest value" (LaRocque 1931). That publication listed over 400 original descriptions.

The present paper aims to bring the little-known but important compilation by LaRocque to the attention of readers, and to up-date the record to include a full century of journal publication. In the following, all of the original descriptions that have appeared in *The Canadian Field-Naturalist* since LaRocque's (1931) paper are listed.

The format used in LaRocque (1931) is followed as much as possible to facilitate comparisons between

the two half centuries of publication. It is recognized that the taxonomic groupings used by Professor LaRocque for invertebrates are quite out of date and were somewhat all-encompassing even for his day (M. J. Copeland, personal communication). Nonetheless, I have followed his arrangement for the sake of consistency. The following abbreviations (taken from LaRocque 1931) are used in the list below:

nom. prov.	= provisional name
gen. nov.	= new genus
subgen. nov.	= new subgenus
sp. nov.	= new species
subsp. nov.	= new subspecies
var. nov.	= new variety
hyb. nov.	= new hybrid
forma nov.	= new form
comb. nov.	= new combination

Following each new name or description, the authority is given, as is the nature of the original description (e.g. sp. nov., var. nov.). On the following line *The Canadian Field-Naturalist* volume number, issue number (in parentheses) and volume year are referred to, followed by the page on which the description appears (or commences). If an illustration of the organism is included with the original description, this is indicated by "Figure" completing the reference. The names are listed alphabetically within the following headings:

- (A) Recent Fauna
 - 1) Birds
 - 2) Invertebrates
 - 3) Mammals
- (B) Recent Flora
 - 4) Algae
 - 5) Fungi

- 6) Bryophytes
- 7) Lichens
- 8) Vascular Plants
- (C) Fossil Fauna
- 9) Mammals
- 10) Reptiles
- 11) Invertebrates

The original descriptions published in *The Canadian Field-Naturalist* between 1932 and 1986 are as follows:

(A) Recent Fauna

- (1) Birds
 - Geothlypis trichas* subsp. *yukonicola* Godfrey, subsp. nov. 64(3) 1950 p. 104; Figure.
 - Grus canadensis* subsp. *rowani* Walkinshaw, subsp. nov. 79(3) 1965 p. 181.
 - Hylocichla ustulata* subsp. *incana* Godfrey, subsp. nov. 65(5) 1951 p. 173.
 - Parus hudsonicus* subsp. *farleyi* Godfrey, subsp. nov. 65(1) 1951 p. 26.

(2) Invertebrates

(Note: LaRocque's (1931) classification of Recent invertebrates did not include any of the following subheadings. Those added here are orders, except for the phylum Rotifera, and are listed alphabetically, not systematically).

ADENOPHOREA

- Capillaria columbae* var. *sturni* Cannon, var. nov. 53(3) 1939 p. 41.

ARACHNIDA

- Ceraticelus rowensis* Levi & Levi, sp. nov. 69(2) 1955 p. 36; Figure.
- Collinsia wilburi* Levi & Levi, sp. nov. 69(2) 1955 p. 35; Figure.
- Lepthyphantes alderstoni* Levi & Levi, sp. nov. 69(2) 1955 p. 33; Figure.
- Lepthyphantes berthae* Levi & Levi, sp. nov. 69(2) 1955 p. 33; Figure.
- Lepthyphantes sammamish* Levi & Levi, sp. nov. 69(2) 1955 p. 33; Figure.
- Tetragnatha numa* Levi & Levi, sp. nov. 69(2) 1955 p. 37; Figure.

CRUSTACEA

- Crangonyx minor* Bousfield, sp. nov. 72(2) 1958 p. 98; Figure.
- Crangonyx pseudogracilis* Bousfield, sp. nov. 72(2) 1958 p. 102; Figure.
- Crangonyx richmondensis* subsp. *laurentianus* Bousfield, subsp. nov. 72(2) 1958 p. 94; Figure.
- Crangonyx rivularis* Bousfield, sp. nov. 72(2) 1958 p. 100; Figure.
- Crangonyx setodactylus* Bousfield, sp. nov. 72(2) 1958 p. 96; Figure.
- Gammarus pseudolimnaeus* Bousfield, sp. nov. 72(2) 1958 p. 74; Figure.

- Mysis gaspensis* O. Tattersall, sp. nov. 68(4) 1954 p. 146; Figure.
- Paramoera carlottensis* Bousfield, sp. nov. 72(2) 1958 p. 64; Figure.
- Paramoera columbiana* Bousfield, sp. nov. 72(2) 1958 p. 62; Figure.
- Scalpellum wyethi* Cornwall, sp. nov. 65(1) 1951 p. 36; Figure.

GASTROPODA

- Gyraulus hornensis* Baker, sp. nov. 48(8) 1934 p. 135; Figure.
- Physella wrightii* Te & Clarke, sp. nov. 99(3) 1985 p. 295; Figure.
- Stagnicola johnsoni* Baker, sp. nov. 48(4) 1934 p. 70; Figure.
- Stagnicola yukonensis* Baker, sp. nov. 48(4) 1934 p. 69; Figure.

ROTIFERA

- Lecane fusilis* Myers, sp. nov. 59(5) 1936 p. 83; Figure.
- Lepadella canadensis* Myers, sp. nov. 50(5) 1936 p. 83; Figure.

(3) Mammals

- Eutamias minimus* subsp. *hudsonius* Anderson & Rand, subsp. nov. 57(7-8) 1943 p. 133.
- Marmota caligata* subsp. *broweri* Hall & Gilmore, subsp. nov. 48(4) 1934 p. 57.
- Microtus townsendi* subsp. *laingi* Anderson & Rand, subsp. nov. 57(4-5) 1943 p. 74.
- Phenacomys ungava* subsp. *laingi* Anderson, subsp. nov. 56(4) 1942 p. 59; Figure.
- Phenacomys ungava* subsp. *soperi* Anderson, subsp. nov. 56(4) 1942 p. 58; Figure.
- Sorex palustris* subsp. *brooksi* Anderson, subsp. nov. 48(8) 1934 p. 134.
- Thomomys talpoides* subsp. *cognatus* Johnstone, subsp. nov. 68(4) 1954 p. 163; Figure.
- Thomomys talpoides* subsp. *segregatus* Johnstone, subsp. nov. 68(4) 1954 p. 161; Figure.

(B) Recent Flora

(4) Algae

- Arthrodesmus ralfsii* var. *brebissonii* (Racib.) Smith forma *limnophilus* (Teil.) Hughes, comb. nov. 66(6) 1952 p. 169.

(5) Fungi

- Aleurodiscus dendroideus* Ginns, sp. nov. 96(2) 1982 p. 131; Figure.

(6) Bryophytes

- Didymodon johansenii* (Williams) Crum, comb. nov. 83(2) 1969 p. 157.
- Timmia norvegica* Zett var. *comata* (Lindb. & Arn.) Crum, comb. nov. 81(2) 1967 p. 114.

(7) Lichens

Aspicila contigua (Lyngé) Thomson, comb. nov.

99(2) 1985 p. 182.

Aspicila humboldtii (Lyngé) Thomson, comb. nov.

99(2) 1985 p. 183.

Aspicila nathorstii (Lyngé) Thomson, comb. nov.

99(2) 1985 p. 183.

(8) Vascular Plants

Acer negundo L. forma *sanguineum* Martin, forma nov.

63(5) 1949 p. 213.

Achillea millefolium L. subsp. *atrotegula* Boivin, subsp. nov.

65(1) 1951 p. 10.

Achillea millefolium L. subsp. *atrotegula* Boivin var. *fulva* Boivin, var. nov.

65(1) 1951 p. 11.

Achillea millefolium L. subsp. *atrotegula* Boivin var. *fulva* Boivin forma *roseiflora* Boivin, forma nov.

65(1) 1951 p. 12.

Achillea millefolium L. subsp. *atrotegula* Boivin var. *parvigula* Boivin, var. nov.

65(1) 1951 p. 11.

Achillea millefolium L. subsp. *atrotegula* Boivin var. *parvula* Boivin, var. nov.

65(1) 1951 p. 11.

Achillea millefolium L. subsp. *pallidotegula* Boivin, subsp. nov.

65(1) 1951 p. 9.

Achillea millefolium L. subsp. *pallidotegula* Boivin var. *megacephala* (Raup) Boivin, comb. nov.

65(1) 1951 p. 10.

Achillea millefolium L. subsp. *pallidotegula* Boivin var. *russeolata* Boivin, var. nov.

65(1) 1951 p. 10.

Agropyron repens Beauv. X *Elymus mollis* Trin.

50(7) 1936 p. 117.

Agropyron trachycaulum (Link) Malte var. *glaucum* (Pease & Moore) Malte X *Hystrix patula* (L.) Moench var.

bigeloviana (Fernald) Deam

64(1) 1950 p. 40; Figure.

Andromeda polifolia L. var. *concolor* Boivin, var. nov.

65(1) 1951 p. 16.

Androsace chamaejasme Host. var. *lehmanniana* (Sprengel) Boivin, comb. nov.

68(3) 1954 p. 116.

Anemone multifida Poir. forma *galactiflora* Boivin, forma nov.

65(1) 1951 p. 2.

Anemone multifida Poir. var. *sansonii* Boivin, var. nov.

65(1) 1951 p. 2.

Anemone multifida Poir. var. *saxicola* Boivin, var. nov.

65(1) 1951 p. 2.

Antennaria breitungii Porsild, sp. nov.

64(1) 1950 p. 18.

Antennaria elegans Porsild, sp. nov.

64(1) 1950 p. 18.

Antennaria incarnata Porsild, sp. nov.

64(1) 1950 p. 19.

Antennaria leontopodioides Cody, sp. nov.

70(3) 1956 p. 127.

Antennaria pedunculata Porsild, sp. nov.

64(1) 1950 p. 15.

Antennaria pulcherrima (Hooker) Greene var. *angustiquama* Porsild, var. nov.

64(1) 1950 p. 11.

Antennaria rousseaui Porsild, sp. nov.

63(2) 1949 p. 80.

Antennaria stolonifera Porsild, sp. nov.

64(1) 1950 p. 16.

Arabis divaricarpa A. Nels. var. *pinetorum* (Tid.) Boivin, comb. nov.

65(1) 1951 p. 16.

Arabis hirsuta (L.) Scop. var. *minshallii* Boivin, var. nov.

65(1) 1951 p. 16.

Arabis retrofracta Graham var. *collinsii* Boivin, var. nov.

65(1) 1951 p. 17.

Arabis retrofracta Graham var. *multicaulis* Boivin, var. nov.

65(1) 1951 p. 17.

Arenaria rubella (Wahl.) Sm. forma *plena* Calder, forma nov.

65(1) 1951 p. 4.

Arnica chamissonis Less. var. *incana* (Gray) Boivin, comb. nov.

65(1) 1951 p. 14.

Artemisia rupestris L. subsp. *woodii* Neilson, subsp. nov.

82(2) 1968 p. 119; Figure.

Aster calderi Boivin, sp. nov.

65(1) 1950 p. 14; Figure.

Aster elegantulus Porsild, sp. nov.

64(1) 1950 p. 43.

Aster sibiricus L. var. *pygmaeus* (Lindl.) Cody, comb. nov.

68(3) 1954 p. 117.

Carex atrofusca Schk. var. *major* (Boeckl.) Raymond, comb. nov.

66(4) 1952 p. 98.

Carex franklinii Boott var. *misandroides* (Fern.) Raymond, comb. nov.

66(4) 1952 p. 102; Figure.

Carex lepageana Raymond, sp. nov.

66(4) 1952 p. 101; Figure.

Carex magnursina Raymond, sp. nov.

66(4) 1952 p. 100; Figure.

Cassiope tetragona (L.) Don. subsp. *saximontana* (Small) Porsild, comb. nov.

54(5) 1940 p. 68.

Cerastium arvense L. var. *purpurascens* Boivin, var. nov.

65(1) 1951 p. 4.

Cerastium nutans Raf. var. *occidentale* Boivin, var. nov.

65(1) 1951 p. 5.

Chenopodium glaucum L. var. *salinum* (Standl.) Boivin, comb. nov.

65(1) 1951 p. 17.

Deschampsia cespitosa (L.) Beauv. var. *intercotidalis* Boivin, var. nov.

65(1) 1951 p. 17.

Dryas alaskensis Porsild, sp. nov.

61(6) 1947 p. 187; Figure.

Dryas drummondii Rich. var. *eglandulosa* Porsild, var. nov.

79(2) 1965 p. 79.

Dryas drummondii Rich. var. *tomentosa* (Farr) Porsild, comb. nov.
 56(7) 1942 p. 112.
Dryas punctata Juz. var. *henricae* (Juz.) Porsild, comb. nov.
 61(6) 1947 p. 186.
Dryas sylvatica (Hult  n) Porsild, comb. nov.
 61(6) 1947 p. 191; Figure.
Dryopteris X *algonquinensis* D. M. Britton, hyb. nov.
 89(2) 1975 p. 165; Figure.
Epilobium latifolium L. subsp. *leucanthum* Ulke, subsp. nov.
 49(6) 1935 p. 108.
Equisetum arvense L. var. *boreale* (Bong.) Rupr. forma *pseudonemorosum* Boivin, forma nov.
 65(1) 1951 p. 18.
Eriophorum opacum (Bjornstr.) Fern. var. *cinnamomeum* Porsild, var. nov.
 56(7) 1942 p. 112.
Eupatorium maculatum L. var. *bruneri* (Gray) Breitung, comb. nov.
 61(3) 1947 p. 98.
Goodyera oblongifolia Raf. var. *reticulata* Boivin, var. nov.
 65(1) 1951 p. 20.
Habenaria orbiculata (Pursh) Goldie forma *trifolia* Mousley, forma nov.
 46(1) 1932 p. 2.
Haplopappus lanceolatus (Hook.) T. & G. var. *sublanatus* Cody, car. nov.
 70(3) 1956 p. 126.
Hedysarum mackenzii Rich. var. *fraseri* Boivin, var. nov.
 65(1) 1951 p. 20.
Hedysarum mackenzii Rich. var. *mackenzii* forma *niveum* Boivin, forma nov.
 65(1) 1951 p. 20.
Hedysarum mackenzii Rich. forma *proliferum* Dore, forma nov.
 73(3) 1959 p. 151; Figure.
Hieracium gracile Hooker var. *yukonense* Porsild, var. nov.
 64(1) 1950 p. 45.
Kalmia polifolia Wang. forma *leucantha* Schofield & Smith, forma nov.
 67(2) 1953 p. 94.
Lychnis apetala L. var. *arctica* (Fries) Cody, comb. nov.
 67(1) 1953 p. 41.
Lychnis apetala L. var. *arctica* (Fries) Cody forma *palea* (Polunin) Cody, comb. nov.
 67(1) 1953 p. 41.
Lychnis apetala L. var. *nutans* Boivin, var. nov.
 65(1) 1951 p. 5.
Lychnis apetala L. var. *nutans* Boivin forma *palea* (Polunin) Boivin, comb. nov.
 65(1) 1951 p. 6.
Lychnis gillettii Boivin, sp. nov.
 65(1) 1951 p. 6; Figure.
Lychnis ostenfeldii (Porsild) Boivin, comb. nov.
 65(1) 1951 p. 6.
Lychnis sorensenii Boivin, sp. nov.
 65(1) 1951 p. 6-7; Figure.

Lycopodium obscurum L. forma *dendroideum* (Michx.) Boivin, comb. nov.
 65(1) 1951 p. 20.
Medicago sativa L. forma *prolifera* Dore, forma nov.
 73(3) 1959 p. 150; Figure.
Melilotus alba Desr. forma *prolifera* Dore, forma nov.
 3(3) 1959 p. 151; Figure.
Nymphaea tetragona Georgi subsp. *leibergeri* (Morong) Porsild, comb. nov.
 53(4) 1939 p. 50.
Oenothera apicaborta Ruggles Gates, sp. nov.
 65(6) 1951 p. 196.
Oenothera magdalena Ruggles Gates, sp. nov.
 65(6) 1951 p. 196.
Oenothera perangusta Ruggles Gates, sp. nov.
 64(4) 1950 p. 142.
Oenothera perangusta Ruggles Gates var. *rubricalyx* Ruggles Gates, var. nov.
 64(4) 1950 p. 143.
Orchis rotundifolia Banks var. *lineata* Mousley, var. nov.
 55(5) 1941 p. 65; Figure.
Osmorrhiza obtusa (Coult. & Rose) Fern. var. *cupressimontanum* Boivin, var. nov.
 65(1) 1951 p. 20.
Oxycooccus ovalifolius (Michx.) Porsild, comb. nov.
 52(8) 1938 p. 117.
Oxytropis jordalii Porsild, sp. nov.
 65(2) 1951 p. 77; Figure.
Oxytropis koyukukensis Porsild, sp. nov.
 65(2) 1951 p. 78; Figure.
Parrya arctica R.Br. forma *albiflora* Boivin, forma nov.
 67(1) 1953 p. 42.
Pedicularis lanata Cham. & Sch. forma *alba* Cody, forma nov.
 65(4) 1951 p. 143.
Pedicularis sudetica Willd. forma *alba* Cody, forma nov.
 65(4) 1951 p. 143.
Poa jordalii Porsild, sp. nov.
 79(2) 1965 p. 82; Figure.
Populus balsamifera L. subsp. *trichocarpa* (T. & G.) Brayshaw, comb. nov.
 79(2) 1965 p. 95.
Populus balsamifera L. subsp. *trichocarpa* (T. & G.) Brayshaw var. *hastata* (Dode) Brayshaw, comb. nov.
 79(2) 1965 p. 95.
Potentilla hyparctica Malte var. *hypartica* forma *tardinx* (Polunin) Savile & Calder, comb. nov.
 66(4) 1952 p. 106.
Potentilla pratensis Boivin, nom. prov.
 65(1) 1951 p. 21.
Potentilla rolandii Boivin, nom. nov.
 65(1) 1951 p. 21.
Potentilla rolandii Boivin var. *lanata* Boivin, var. nov.
 65(1) 1951 p. 21.
Primula tschuktschorum Kjellm. subsp. *cairnesiana* Porsild, subsp. nov.
 79(2) 1965 p. 89; Figure.
Primula tschuktschorum Kjellm. subsp. *eximia* (Greene) Porsild, comb. nov.
 79(2) 1965 p. 87.

Primula tschuktschorum Kjellm. subsp. *tschuktschorum* var. *beringensis* Porsild, var. nov.
79(2) 1965 p. 87; Figure.

Ranunculus acris L. var. *stevenii* (Andrz.) Lange forma *multiplicipetalus* Boivin, forma nov.
65(1) 1951 p. 3.

Ranunculus buddii Boivin, sp. nov.
65(1) 1951 p. 3; Figure.

Ranunculus buddii Boivin forma *monochlamydeus* Boivin, forma nov.
65(1) 1951 p. 3.

Ranunculus codyanus Boivin, sp. nov.
65(1) 1951 p. 3; Figure.

Ranunculus flabellaris Raf. forma *plenus* Boivin, forma nov.
65(1) 1951 p. 4.

Ranunculus hyperboreus Rottb. forma *integrescens* Savile & Calder, forma nov.
66(4) 1952 p. 105.

Ranunculus hyperboreus Rottb. forma *turquetilianus* (Polunin) Calder & Savile, comb. nov.
66(4) 1952 p. 105.

Ranunculus inamoenus Greene var. *elator* Boivin, var. nov.
65(1) 1951 p. 4.

Ranunculus pedatifidus Sm. var. *cardiophyllus* (Hook.) Britt. forma *apetalus* (Farr) Boivin, forma nov.
65(1) 1951 p. 4.

Rosa rousseauiorum Boivin forma *chrysocarpa* (Boivin) Boivin, forma nov.
65(1) 1954 p. 21.

Rosa woodsii Lindl. var. *terrens* (Lunell) Breitung, comb. nov.
68(2) 1954 p. 82.

Sarracenia purpurea L. forma *plena* Erskine, forma nov.
69(3) 1955 p. 129.

Sarracenia purpurea L. var. *ripicola* Boivin, var. nov.
65(1) 1951 p. 21.

Sarracenia purpurea L. var. *terrae-novae* Pyl. forma *heterophylla* (Eaton) Boivin, forma nov.
65(1) 1951 p. 22.

Saxifraga caespitosa L. forma *multiflora* Calder, forma nov.
65(5) 1951 p. 183.

Saxifraga tricuspidata Rottb. forma *ligulata* Savile & Calder, forma nov.
66(4) 1952 p. 105.

Saxifraga tricuspidata Rottb. forma *woodruffii* Calder, forma nov.
64(2) 1950 p. 92.

Senecio sheldonensis Porsild, sp. nov.
64(1) 1950 p. 43.

Senecio yukonensis Porsild, sp. nov.
64(1) 1950 p. 44.

Smilacina amplexicaulis Nutt. var. *jenkinsii* Boivin, var. nov.
65(1) 1951 p. 14.

Smilacina amplexicaulis Nutt. var. *ovata* Boivin, var. nov.
65(1) 1951 p. 15.

Smilacina racemosa (L.) Desf. var. *lanceolata* Boivin, var. nov.
65(1) 1951 p. 16.

Solidago puberula Nutt. forma *albiradiata* Schofield & Smith, forma nov.
67(2) 1953 p. 94.

Spiranthes lacera (Raf.) Raf. var. *lacera* X *Spiranthes romanzoffiana* Cham.
92(4) 1978 p. 350; Figure.

Stellaria calycantha (Led.) Bong. var. *latifolia* Boivin, var. nov.
65(1) 1951 p. 7.

Stellaria monantha Hult  n var. *atlantica* (Hult  n) Boivin, comb. nov.
65(1) 1951 p. 7.

Taraxacum pellanum Porsild, sp. nov.
64(1) 1950 p. 44.

Thalictrum breitungii Boivin, sp. nov.
62(6) 1948 p. 168.

Thalictrum fissum Greene var. *greeneanum* Boivin, var. nov.
62(6) 1948 p. 168.

Thalictrum turneri Boivin, sp. nov.
62(6) 1948 p. 167.

Trifolium hybridum L. forma *allioideum* Dore, forma nov.
73(3) 1959 p. 153; Figure.

Trifolium hybridum L. forma *proliferum* Dore, forma nov.
73(3) 1959 p. 150; Figure.

Trifolium repens L. forma *allioideum* Dore, forma nov.
73(3) 1959 p. 153; Figure.

Vaccinium boreale Hall & Aalders X *Vaccinium myrtilloides* Michx.
76(4) 1962 p. 203.

Viola russellii Boivin, sp. nov.
65(1) 1951 p. 22; Figure.

(C) Fossil Fauna

(9) Mammals

Merychippus praecocidens Russell, sp. nov.
47(1) 1933 p. 11; Figure.

(10) Reptiles

Leidyosuchus acutidentatus Sternberg, sp. nov.
46(6) 1932 p. 128; Figure.

Macrophalangia Sternberg, gen. nov.
46(5) 1932 p. 100.

Macrophalangia canadensis Sternberg, sp. nov.
46(5) 1932 p. 100; Figure.

Ornithomimus edmontonicus Sternberg, sp. nov.
47(5) 1933 p. 79; Figure.

Stenonychosarus Sternberg, gen. nov.
46(5) 1932 p. 102.

Stenonychosarus inequalis Sternberg, sp. nov.
46(5) 1932 p. 102; Figure.

(11) Invertebrates

ANTHOZOA

Tetradium clarki Okulitch, sp. nov.
49(6) 1935 p. 96; Figure.

GRAPTOLITHINA (Graptolitoidea)

Retiolites geinitzianus var. *maximus* Ruedemann, var. nov.
52(2) 1938 p. 19; Figure.

ECHINODERMATA

- Amecystis cordiformis* Sinclair, sp. nov.
59(3) 1945 p. 72; Figure.
Comptonia stelcki McLearn, nom. prov.
58(4) 1944 p. 133; Figure.
Glyptocystites grandis Sinclair, sp. nov.
59(3) 1945 p. 73; Figure.
Lophidiaster silentiensis McLearn, sp. nov.
58(4) 1944 p. 133; Figure.

BRACHIOPODA

- Coenothyris petriana* McLearn, sp. nov.
51(7) 1937 p. 95; Figure.
Coenothyris silvana McLearn, sp. nov.
51(7) 1937 p. 96; Figure.
Doleroides pervetus var. *ottawanus* Wilson, var. nov.
45(6) 1932 p. 136.
Leptaena radialis Okulitch, sp. nov.
49(6) 1935 p. 99; Figure.
Onniella paquettensis Sinclair, sp. nov.
59(3) 1945 p. 73; Figure.
Pionodema sinuata Okulitch, sp. nov.
49(6) 1935 p. 97; Figure.
Rafinesquina clara Okulitch, sp. nov.
49(6) 1935 p. 97; Figure.
Rafinesquina grandis Okulitch, sp. nov.
49(6) 1935 p. 98; Figure.
Rafinesquina rugosa var. *avita* Wilson, var. nov.
46(6) 1932 p. 138; Figure.
Rafinesquina transitionalis Okulitch, sp. nov.
49(6) 1935 p. 97; Figure.
Rafinesquina wagneri Okulitch, sp. nov.
49(6) 1935 p. 98; Figure.
Rafinesquina williamsi Okulitch, sp. nov.
49(6) 1935 p. 98; Figure.
Spiriferina onestae McLearn, sp. nov.
51(7) 1937 p. 96; Figure.
Strophomena corrugata Okulitch, sp. nov.
49(6) 1935 p. 99; Figure.

PELECYPODA

- Aviculomyalina williamsi* McLearn, nom. prov.
55(3) 1941 p. 31; Figure.
Cassianella beyrichi var. *crickmayi* McLearn, var. nov.
56(7) 1942 p. 99; Figure.
Daonella nitanae McLearn, sp. nov.
31(7) 1937 p. 96; Figure.
Gryphaea chakii McLearn, sp. nov.
31(7) 1937 p. 96; Figure.
Halobia pacalis McLearn, sp. nov.
54(8) 1940 p. 111; Figure.
Halobia symmetrica var. *lata* McLearn, var. nov.
54(8) 1940 p. 111; Figure.
Hoernesia woyaniana McLearn, nom. prov.
51(7) 1937 p. 96; Figure.
Inoceramus athabaskensis McLearn, sp. nov.
57(2-3) 1943 p. 44; Figure.
Inoceramus cadottensis var. *altifluminis* McLearn, var. nov.
57(2-3) 1943 p. 43; Figure.
Inoceramus fragilis var. *priariensis* McLearn, var. nov.
57(2) 1943 p. 44; Figure.

- Inoceramus leylandensis* McLearn, sp. nov.
57(2-3) 1943 p. 44; Figure.
Inoceramus leylandensis var. *bighornensis* McLearn, var. nov.
57(2-3) 1943 p. 44; Figure.
Inoceramus nahwisi var. *goodrichensis* McLearn, var. nov.
57(2-3) 1943 p. 45; Figure.
Inoceramus nahwisi var. *moberliensis* McLearn, var. nov.
57(2-3) 1943 p. 46; Figure.
Inoceramus pontoni var. *dolosoniensis* McLearn, var. nov.
57(2-3) 1943 p. 45; Figure.
Lima childerhosei McLearn, sp. nov.
55(3) 1941 p. 32; Figure.
Lima nappii McLearn, sp. nov.
51(9) 1937 p. 131; Figure.
Lima poyana McLearn, sp. nov.
31(7) 1937 p. 96; Figure.
Macrodon tyaughtonae McLearn, sp. nov.
56(7) 1942 p. 99; Figure.
Modiolus ahsisi McLearn, sp. nov.
51(7) 1937 p. 96; Figure.
Modiolus ahsisi var. *stelcki* McLearn, var. nov.
53(8) 1939 p. 120; Figure.
Monotis ireneana McLearn, nom. prov.
51(9) 1937 p. 131; Figure.
Monotis montini McLearn, sp. nov.
51(7) 1937 p. 96; Figure.
Myoconcha amnipacis McLearn, sp. nov.
55(3) 1941 p. 33; Figure.
Myoconcha cauriniensis McLearn, sp. nov.
53(8) 1939 p. 120; Figure.
Myoconcha curionii var. *chenekai* McLearn, var. nov.
55(3) 1941 p. 32; Figure.
Myoconcha curionii var. *montipetraea* McLearn, var. nov.
55(3) 1941 p. 32; Figure.
Myophoria adornata McLearn, sp. nov.
56(7) 1942 p. 101; Figure.
Myophoria cairnesi McLearn, sp. nov.
56(7) 1942 p. 101; Figure.
Myophoria columbiana McLearn, sp. nov.
56(7) 1942 p. 100; Figure.
Myophoria grahami McLearn, sp. nov.
55(3) 1941 p. 31; Figure.
Myophoria morigera McLearn, sp. nov.
54(8) 1940 p. 112; Figure.
Myophoria silentiana McLearn, sp. nov.
53(8) 1939 p. 118; Figure.
Myophoria zeballos McLearn, sp. nov.
56(7) 1942 p. 101; Figure.
Mytilus shulapsensis McLearn, nom. prov.
56(7) 1942 p. 102; Figure.
Palaeocardita glaukos McLearn, sp. nov.
55(3) 1941 p. 33; Figure.
Pecten cadwalladerensis McLearn, sp. nov.
56(7) 1942 p. 103; Figure.

Pecten chiwanae McLearn, sp. nov.
55(3) 1941 p. 32; Figure.
Pecten dishinni McLearn, nom. prov.
54(8) 1940 p. 112; Figure.
Pecten dishinni var. *kaska* McLearn, var. nov.
54(8) 1940 p. 112; Figure.
Pecten nihanianus McLearn, sp. nov.
53(8) 1939 p. 118; Figure.
Pecten nihanianus var. *dresseri* McLearn, var. nov.
53(8) 1939 p. 120; Figure.
Pecten otianus McLearn, sp. nov.
53(8) 1939 p. 120; Figure.
Pecten pontiamnis McLearn, sp. nov.
56(7) 1942 p. 102; Figure.
Pecten sarsianus McLearn, sp. nov.
51(9) 1937 p. 131; Figure.
Pecten sasuchan McLearn, sp. nov.
55(3) 1941 p. 32; Figure.
Pecten tranquillianus McLearn, sp. nov.
53(8) 1939 p. 120; Figure.
Pecten tyaughtonae McLearn, sp. nov.
56(7) 1942 p. 102; Figure.
Pisidium squamula Russell, sp. nov.
46(4) 1932 p. 81; Figure.
Pleuromya nidovana McLearn, nom. prov.
51(9) 1937 p. 131; Figure.
Pleurophorus kissoumi McLearn, sp. nov.
53(8) 1939 p. 120; Figure.
Pteria colliplana McLearn, nom. prov.
53(8) 1939 p. 118; Figure.
Pteria laksel McLearn, nom. prov.
55(3) 1941 p. 31; Figure.
Sphaerium livingstonensis Russell, sp. nov.
46(4) 1932 p. 80; Figure.
Sphaerium mclearni Russell, sp. nov.
46(4) 1932 p. 80; Figure.

GASTROPODA

Buchites hilaris var. *dawsoni* McLearn, var. nov.
54(4) 1940 p. 49; Figure.
Goniobasis sanctamariensis Russell, sp. nov.
46(4) 1932 p. 81; Figure.
Gyraulus cyclostomus Baker, sp. nov.
48(2) 1934 p. 37; Figure.
Homotoma wilsoni Okulitch, sp. nov.
49(6) 1935 p. 100; Figure.
Liospira peneplana Okulitch, sp. nov.
49(6) 1935 p. 100; Figure.
Trochonemella Okulitch, gen. nov.
49(6) 1935 p. 101; Figure.
Trochonemella montrealensis Okulitch, sp. nov.
49(6) 1935 p. 101; Figure.
Valvata lewisi var. *mccolli* LaRocque, var. nov.
46(9) 1932 p. 199; Figure.

CEPHALOPODA

Asklepioceras glaciense McLearn, sp. nov.
54(4) 1940 p. 51; Figure.
Asklepioceras laurenci McLearn, sp. nov.
54(4) 1940 p. 51; Figure.
Beloitoceras agaricus Flower, sp. nov.
59(3) 1945 p. 75; Figure.

Beloitoceras cartierense Flower, sp. nov.
59(3) 1945 p. 76; Figure.
Beloitoceras imitans Flower, sp. nov.
59(3) 1945 p. 77; Figure.
Cyrtorizoceras rougense Flower, sp. nov.
59(3) 1945 p. 80; Figure.
Daphnites stelcki McLearn, sp. nov.
54(4) 1940 p. 50; Figure.
Distichites gethingi McLearn, sp. nov.
54(8) 1940 p. 116; Figure.
Distichites loidli var. *canadensis* McLearn, var. nov.
54(4) 1940 p. 50; Figure.
Drepanites rutherfordi McLearn, sp. nov.
51(7) 1937 p. 98; Figure.
Helictites decorus McLearn, sp. nov.
54(4) 1940 p. 49; Figure.
Helictites decorus var. *obesus* McLearn, var. nov.
54(4) 1940 p. 50; Figure.
Helictites decorus var. *transitionis* McLearn, var. nov.
54(4) 1940 p. 50; Figure.
Hendersonia Wilson, gen. nov.
52(1) 1938 p. 2; Figure.
Hendersonia sola Wilson, sp. nov.
52(1) 1938 p. 2; Figure.
Himavatites canadensis McLearn, sp. nov.
54(8) 1940 p. 115; Figure.
Isculites schooleri var. *parvus* McLearn, sp. nov.
51(7) 1937 p. 98; Figure.
Juvavites belli McLearn, sp. nov.
54(8) 1940 p. 114; Figure.
Juvavites biornatus McLearn, sp. nov.
54(4) 1940 p. 48; Figure.
Juvavites bococki McLearn, sp. nov.
51(7) 1937 p. 98; Figure.
Juvavites butleri McLearn, sp. nov.
54(8) 1940 p. 114; Figure.
Juvavites concretus McLearn, sp. nov.
54(8) 1940 p. 113; Figure.
Juvavites custi McLearn, sp. nov.
54(8) 1940 p. 113; Figure.
Juvavites fuscus McLearn, sp. nov.
54(8) 1940 p. 114; Figure.
Juvavites humi McLearn, sp. nov.
51(9) 1937 p. 130; Figure.
Juvavites mackenzii McLearn, sp. nov.
51(9) 1937 p. 130; Figure.
Juvavites magnus McLearn, sp. nov.
54(4) 1940 p. 48; Figure.
Juvavites mclayi McLearn, sp. nov.
54(8) 1940 p. 113; Figure.
Juvavites mertoni McLearn, sp. nov.
51(9) 1937 p. 130; Figure.
Juvavites parvus McLearn, sp. nov.
54(8) 1940 p. 115; Figure.
Juvavites pardoniensis McLearn, sp. nov.
54(4) 1940 p. 48; Figure.
Juvavites rarus McLearn, sp. nov.
54(8) 1940 p. 114; Figure.
Juvavites selwyni McLearn, sp. nov.
54(8) 1940 p. 113; Figure.

Juvavites spiekeri McLearn, sp. nov.
51(9) 1937 p. 130; Figure.
Liskeardia Wilson, gen. nov.
53(8) 1939 p. 124.
Lobites pacianus McLearn, sp. nov.
51(7) 1937 p. 96; Figure.
Malayites dawsoni McLearn, sp. nov.
51(9) 1937 p. 130; Figure.
Nitanoceras McLearn, gen. nov.
51(7) 1937 p. 96.
Oncoceras minor Flower, sp. nov.
59(3) 1945 p. 77; Figure.
Oncoceras orthodomum Flower, sp. nov.
59(3) 1945 p. 78; Figure.
Oncoceras planidorsatum Flower, sp. nov.
59(3) 1945 p. 79; Figure.
Pterotoceras caurinum var. *arctum* McLearn, var. nov.
54(8) 1940 p. 115; Figure.
Sagenites gethingi McLearn, sp. nov.
51(7) 1937 p. 98; Figure.
Sirenites pardoneii McLearn, sp. nov.
54(8) 1940 p. 115; Figure.
Stikinoceras robustum McLearn, sp. nov.
51(7) 1937 p. 98; Figure.
Styrites columbianus McLearn, sp. nov.
54(4) 1940 p. 48; Figure.
Styrites ireneanus McLearn, sp. nov.
54(4) 1940 p. 48; Figure.
Thisbites charybdis var. *custi* McLearn, var. nov.
54(4) 1940 p. 49; Figure.
Thisbites charybdis var. *ireneanus* McLearn, var. nov.
54(4) 1940 p. 49; Figure.

TRILOBITA

Alsataspis evansi Kindle, sp. nov.
54(4) 1942 p. 33; Figure.
Illaeus lemontensis Tasch, sp. nov.
65(5) 1951 p. 165; Figure.
Illaeus martineauensis Okulitch, sp. nov.
49(6) 1935 p. 102; Figure.
Olenellus hermani Kindle & Tasch, sp. nov.
62(5) 1948 p. 136; Figure.
Pterygometopus harrisi Okulitch, sp. nov.
49(6) 1935 p. 102; Figure.

CONULARIIDA*

Eoconularia Sinclair, gen. nov.
57(7-8) 1943 p. 123.
Eoconularia loculata (Winman), comb. nov.
57(7-8) 1943 p. 123.
Paraconularia Sinclair, subgen. nov.
54(5) 1940 p. 73.

Discussion

Figure 1 summarizes the total number of descriptions that have appeared in *The Canadian Field-Naturalist* and its predecessors. (Pre-1932 totals

(*This phylum was recently (1986) erected (*fide* M. J. Copeland); there is no equivalent in LaRocque's (1931) list.)

FLORA		1880-1931	1932-1986	Total
Fossil	All groups	5	0	5
Modern	Fungi	0	1	1
	Algae	0	1	1
	Lichens	24	3	27
	Bryophytes	91	2	93
	Vasculars	124	129	253
Subtotal		244	136	380

FAUNA		1880-1931	1932-1986	Total
Fossil	Fish	3	0	3
	Reptiles	20	6	26
	Mammals	2	1	3
	Invertebrates	122	140	262
Modern	Fish	2	0	2
	Birds	2	4	6
	Mammals	3	8	11
	Insects	3	0	3
	Other Invertebrates	14	23	37
Subtotal		171	182	353

TOTAL	415	318	733
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FIGURE 1. Summary of original descriptions in the Ottawa Field-Naturalists' Club publications, 1880-1986.

are taken directly from LaRocque 1931.) In this table some striking differences between the publication patterns of the two half centuries are apparent. These are briefly outlined below.

The number of original descriptions of plants dropped off significantly after 1931. This is due in large part to the unusually large production by two authors in the early period rather than to an overall decline in this area. Vascular plant taxonomist E. L. Greene published 76 new names and bryologist N. C. Kindburg published 91 new names, all in the 1890-1910 period. Many, if not most of them, are now treated as synonyms for previously described taxa (cf. Kartesz and Kartesz 1980; Ireland et al. 1980). Similarly, a large group of new names were published by vascular plant taxonomist B. Boivin (54 names) in the later period.

Names of new fossils represent the largest group of original descriptions in *The Canadian Field-Naturalist* and are fairly evenly balanced between the two half centuries. The dinosaur descriptions of L. M. Lamb early in this century represent a small but important group, as do C. M. Sternberg's dinosaur names in the early 1930s. The largest group of fossil names, however, represents invertebrates. A wide

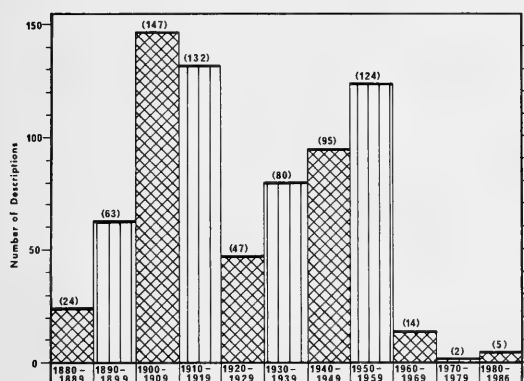


FIGURE 2. Number of original descriptions and new names in the Ottawa Field-Naturalists' Club publications in ten-year periods between 1880 and 1986. (Last period, 1980-1986, represents only seven years).

variety of organisms were described in the first half century by a wide variety of authors, including such notables as W. R. Billings, F. H. McLearn, J. F. Whiteaves and T. H. Clarke. The vast majority of descriptions after 1931 were by F. H. McLearn of the Geological Survey of Canada (96 names). No one published more new names than did McLearn during the 1930s and 1940s. This prolific output is all the more remarkable in light of the absence of financial support for his publication efforts; much of the cost was personally absorbed (Zaslow 1975).

Figure 2 illustrates the total number of new names published in *The Canadian Field-Naturalist* and its predecessors in 10-year blocks. From this figure it is clear that the publication of new names increased in frequency in the first half century, reaching a peak just before World War I. The significant drop after the war likely reflects the reduced level of research conducted during this war period. Activity increased steadily again through the late 1920s and on into the late 1950s. The dramatic drop in the publication of new names after 1960 apparently reflects the preference of contemporary scientists for publishing new taxa in more specialized journals.

In total, 733 original descriptions have appeared in *The Canadian Field-Naturalist* and its predecessors. Of these, 24 were published in the *Transactions of the*

Ottawa Field-Naturalists' Club (1880-1886), 324 in the *Ottawa Naturalist* (1887-1918) and 367 in *The Canadian Field-Naturalist* (1919-1986). While many of these names have since been relegated to synonymy by later workers, many others have stood the test of time. A striking characteristic of the publication of new names in this journal has been the dominance of a relatively small number of authors who have produced a disproportionate number of new names in a particular period.

Although the publication of original descriptions is occurring with less frequency now, this ongoing product of the studies published in *The Canadian Field-Naturalist* offers additional testimony to the important contribution to Canadian life sciences of over a century of Ottawa Field-Naturalists' Club publications.

Acknowledgments

I greatly appreciate the efforts of D. Laubitz, National Museum of Natural Sciences, and W. J. Cody, Agriculture Canada, in providing critical and careful reviews of the manuscript. Laubitz also helped with the arrangement of recent invertebrates and a number of the fossil genera. M. J. Copeland, Geological Survey of Canada, offered an invaluable service in assigning the majority of invertebrate genera into the categories of LaRocque (1931) and clarifying the limitations of that classification for me.

Literature Cited

- Ireland, R. R., C. D. Bird, G. R. Brassard, W. B. Schofield, and D. H. Vitt. 1980. Checklist of the mosses of Canada. Publications in Botany Number 8, National Museum of Natural Sciences, Ottawa. 75 pp.
- Kartesz, J. T., and R. Kartesz. 1980. A synonymized checklist of the vascular flora of the United States, Canada and Greenland. University of North Carolina, Chapel Hill, North Carolina. 500 pp.
- LaRocque, A. 1931. List of original descriptions published by The Ottawa Field-Naturalists' Club. *Canadian Field-Naturalist* 45: 214-222.
- Zaslow, M. 1975. Reading the rocks: the story of the Geological Survey of Canada, 1842-1972. Macmillan Company of Canada, Toronto. 599 pp.

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Book Reviews

ZOOLOGY

Wildfowl in Great Britain

By Myrfin Owen, G. L. Atkinson-Willes, and D. G. Salmon. Illustrated by Sir Peter Scott. 1986. Second Edition. Cambridge University Press, New York. 613 pp., illus. U.S. \$54.50.

Earlier this year I visited several major waterfowl wintering areas in Great Britain. I took great pleasure in seeing vast flocks of Eurasian Wigeon, Pintail, Pochard, Tufted Duck, White-fronted, Brent, and Pink-footed geese. These were spiced with smaller numbers of swans (three species) and more unusual ducks, such as Smew and Red-crested Pochard. After reading this book, I realised that I was able to enjoy these sights only because of a dedicated effort by many people for many years. I also learned that the future is far from secure and this dedicated effort must continue. *Wildfowl in Great Britain* is divided into four parts; the first being an introduction; the second, a summary of the status of wildfowl; the third, species accounts; and the last, a commentary on conservation.

The second and largest part, a survey of wildfowl habitat and distribution, is divided into nine sections, principally by major watershed region. I will use the east and central England section as an example of the book's content, as this is where I spent most of my time on my latest visit. This area covers the Norfolk Broads, the Wash, the Fens, the Ouse, Humber and Trent watersheds, and the North Yorkshire Moors. Throughout the text there is a general lament over the lack of data. From a North American perspective, however, there is a formidable amount of precise information. Clearly the British have been able to mobilize a large number of volunteers, for several years at a time, to seek and count waterfowl. They have not reserved their efforts for the large and spectacular concentrations but documented small populations at minor gravel pits, lakes, and reservoirs.

The authors have used these numbers to evaluate changes in population. Such changes are related to alterations in habitat or other influential changes in ecology (rises in predatory gull populations for example). Generally the story is rather a frustrating one, with many examples of deteriorating populations. Even when a decline has been prevented, say by preserving habitat, the fight is clearly not over. Even

areas that are protected, like the R.S.P.B. and Wildfowl Trust's reserves near Welney, require constant monitoring and maintenance. However, these sanctuaries show relatively stable or even increasing populations. But the pressures by other recreational uses (boating and fishing) are high and this is having a negative effect.

Not all human intervention is detrimental. Ironically the vast Norfolk Broads and the myriad of gravel pits (Little Paxton gravel pit, a small waterbody, is the eighth most important site for wintering Gadwall) are the result of mining for peat and gravel respectively. Whatever the origin of the habitat, however small it is, and no matter the commonness of the species, each bird seems cherished.

The species accounts deal with the birds' ecology, especially those factors which influence survival and reproduction. Here again though, the emphasis is on the numbers and distribution. As the approach is from the species viewpoint, the evaluation is different. This altered perspective is valuable and highlights the enormous value and variety of uses of the field data. It is possible, for example, to compare a local decline (or expansion) to the population in Britain generally. Thus the effects of local changes can be held in perspective and the priorities for further work logically established.

The final section is on the conservation of wildfowl and their habitats. This section is skillfully written and will be of value to those interested in conservation. The influence of human activity is profound. The primary impact is that of the agricultural industry, with its massive, habitat-changing methods. One small surprise, was that it was not the introduction of diesel or steam power that made the most dramatic change in the Fen district but the arrival of windmills! However, all of human activity is reviewed in carefully-researched detail and water-based recreation, flood control, lead poisoning, pollution (industrial, agricultural and oil), hunting, and the positive-negative effects of sewage are all discussed. Amazingly, despite an enviable mountain of statistics, the effects of hunting cannot be unravelled from the mass of complex population figures.

The last two chapters are on management of stocks and conservation. These are more thought provoking and bring into focus the objective of all the work. In many ways the discussions cover the issues facing all conservationists. It is also a testament to what can be done if the effort and will are there.

Where appropriate, other birds for which "wildfowl" habitat is important, such as Ruff, Godwits etc, are also discussed. The book does not confine itself to British data but, when it is meaningful, pulls in a European or North American perspective.

The statistics are well displayed in tables, charts, histograms, and graphs. This makes it easy to read and interpret. The authors have also made excellent use of maps to support their discussions. Sir Peter Scott's line drawings are interspersed between paragraphs, sections and chapters. They are delightful, as one might expect from so famous an artist, depicting both birds and habitat.

This most useful book shows what value can be achieved by a coordinated effort by all those interested in birds. We can be envious of what the British (and the other Europeans) have achieved to date. We can also take heart that this is happening here. The *Ontario Breeding Bird Atlas* has spawned a new series of cooperative projects. But for now we can benefit from the useful information in *Wildfowl in Great Britain*. Anyone interested in conservation on a practical, political or scientific level will find much of use and much to enjoy.

The book ends on an optimistic note. The authors believe that all this effort is making a positive contribution to keeping wildfowl as a significant and enjoyable part of Britain's wildlife. I agree and thank them for this book and the opportunity to see the results in the field.

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The Natural History of Butterflies

By John Feltwell. 1986. Facts on File Natural History Series. Facts on File, New York. xvii + 133 pp., illus. U.S.\$19.95.

In his preface to this book the author clearly describes his intention of reaching an audience of hobbyists and amateur naturalists. That aim he has certainly been able to achieve, though the wealth of authoritative information in this book will be of interest to professionals as well.

This is a natural history rather than a field guide, so the fact that the butterflies described are native to Europe and North Africa does not detract from its appeal to a Canadian audience. Noteworthy are the sections on the behaviour, ecology, and conservation of butterflies, concepts often scantily covered in field guides.

This is an attractive book. Format is appealing, and the clear print on quality paper is very easily read. Information is presented under general headings; unfortunately the first chapter is a rather dry and textbookish historical perspective. However, later chapters on biology and behaviour are presented in a lighter and more interesting style. The section on food plants contains a wealth of fascinating detail, though one might wonder on what basis the plant food groups were chosen for inclusion. A strong plea for habitat conservation is made by the author in the final chapter of the book.

Twenty excellent photographs, beautifully reproduced, illustrate butterflies representative of the

topics covered in the text: e.g. Painted Lady (*Cynthia cardui*) as an example of a migrating butterfly; the Black Satyr (*Satyrus actaea*) as an illustration of the concept of dark butterflies at high elevations absorbing as much of the sun's energy as possible. However, the very detailed and complete captions are located at the book's beginning, while the plates are in the middle of the main text. As a consequence, the plate use is made rather awkward. It is not clear, as well, why the family names are given with some, but not all captions. Black-and-white illustrations scattered throughout the text give helpful and interesting visual detail.

Though two indexes are included, the General Index presents the major weakness of this book. The text documents and ties together a great deal of information from many sources, studies, and experiments. To locate specific data in the book, however, the table of contents is likely to be more useful than the index. Many of the headings used are confusing; "whites and yellows" is a listing, but no listing for "yellows" is included. Six listings begin with the descriptor "large" instead of the nouns following, and this is common throughout the index. Consequently, believe it or not, twenty-five fritillaries are listed under no less than twelve different letter sections, none of which is the letter "f"! The Scientific Names Index is, thankfully, much clearer and more easily used.

The bibliography is a useful list of source materials, though primarily relating to Old World butterflies.

John Feltwell does succeed in making some very technical information appealing and understandable, especially to the non-professional student of butterflies. This natural history is well worth

acquiring as a companion to the more commonly available butterfly field guides.

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The Birds of Africa, Volume II

By Emil K. Urban, C. Hilary Fry, and Stuart Keith. 1986. Academic Press, New York. xvi + 552 pp., illus. U.S.\$99.00.

Book and art exhibits and sales are now as much part of scientific congresses as are symposia, plenary lectures, and poster sessions. The publication of *Birds of Africa*, Volume II was timed to coincide with the 19th International Ornithological Congress, held at Ottawa in June 1986. In addition to signed copies of the new book, Martin Woodcock's original colour painting and Ian Willis's pen and ink drawings were exhibited and available for prospective buyers.

This volume, as was its predecessor, is a cooperative venture. A brainchild of the late Leslie Brown, it is the second in a projected series of six comprehensive handbooks on the birds of Africa. C. Hilary Fry and Stuart Keith, advisory editors to Volume I, joined Emil K. Urban as editors of this and subsequent volumes, which contain up-to-date information, provided by numerous experts, on the African avifauna.

Although the original Introduction to Volume I will have to serve for the entire series, the present volume contains two important new sections: one on Superspecies and another on Nomenclature and Systematics. Additionally it discusses Range and Status, Maps, Description and Field Character, General Habits and Breeding Habits, and the volume's Reference System.

The use of the concept of superspecies is an important innovation by the editors and authors. The term was first used by Ernst Mayr in 1931, and had undergone a number of refinements of definition. According to Dean Amadon, superspecies consist of "a group of entirely or essentially allopatric taxa that were once races of a single species but which now have achieved species status." Because of the size of the African continent where "numerous kinds of birds have vast ranges, and they vary geographically in plumage, size, or behaviour" the editors have opted for the use of the superspecies concept. They admit that their decisions concerning whether or not a species had differentiated to specific level is arbitrary. Such decisions were based on untestable predictions

concerning how two populations would behave reproductively "were they ever to meet naturally." The use of superspecies, consisting of allospecies or geographical replacement species, allowed the authors and editors to modify the textual treatment accorded to each bird. Thus each superspecies is indicated on one range map, and textual abbreviations became possible "as a result of cross-reference between allospecies." Moreover, the editors state that the reader is able "to extrapolate data about a well-known bird to its poorly known allospecies with confidence."

The editors have also instituted a number of changes in the English names of African birds, because of their belief that every African bird should "have a name that clearly distinguishes it from every other bird in the world." In many instances this view necessitated adding "African" to a name commonly used for different species in separate geographical areas of the world. At the same time, acknowledging the importance of tradition, the editors retained many old names. For exclusively African birds "restrictive" regional names have been replaced with broader, descriptive ones. Changes in taxonomic status necessitated the coining of new, more appropriate names.

The main body of the text deals with five orders of birds: Galliformes, Gruiformes, Charadriiformes, Pterocliiformes, and Columbiformes. A brief General Introduction to each order, family, subfamily, and genus is followed by Range and Status, Description, Field Character, Voice, General Habits, Food, and Breeding Habits. In the case of superspecies, description of all but the first allospecies is much abbreviated. For Palearctic birds that winter in Africa, breeding habits are not discussed. For African breeders, where detailed information is available, the section on Breeding Habits includes discussions on mating system, dispersion, courtship behaviour, nest, eggs, laying data, incubation development, care of young and breeding success/survival. Geographical variations in habits, as before, are included in the text, a very useful characteristic of this series. Useful range maps accompany each species or superspecies.

The book contains 32 full size plates of illustrations, of which 28 are in colour. These are, on the whole, attractively arranged to avoid overcrowding. Names of the illustrated birds, with sex, breeding status, plumage, and appropriate text page numbers are indicated on full-size outlines on the page facing each plate. Plate number and position are also well indicated in the text, in line with the name of the species in question. Species descriptions match the illustrations in most cases — a random sampling picked up a few discrepancies, however. For instance the Collared Pratincole (*Glareola pratincola*) is supposed to have white outer retrices, which are not visible on the colour plate, but no black lores which, on my copy at least, are! The Baird's Sandpiper (*Calidris bairdii*), is correctly described as having long wings, which at rest project beyond its tail, but on the illustration this feature, a useful field mark, is not shown. There are others, all of which can be easily remedied for subsequent editions.

As in the previous volume, there are many useful references. Each section contains a few, while the

Bibliography consists of an exhaustive list of General and Regional references in addition to those pertaining to each of the families discussed in the book. A very useful innovation is the list of acoustic references, compiled by Claude Chappuis, which includes disks, cassettes, and institutions with sound recordings. There are three indices, of scientific, English, and French names used.

The book is a commendable addition to the literature on the African avifauna. Its large size and steep price notwithstanding, I would recommend it to all serious naturalists. However, I would like to reiterate my earlier suggestion to Academic Press, that a lower priced paperback edition would enhance the usefulness of this series by making the painstaking work of so many authors, artists and editors available to most naturalists.

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Wildlife 2000: Modeling Habitat Relationships of Terrestrial Vertebrates

Edited by Jared Verner, Michael L. Morrison, and C. John Ralph. 1986. The University of Wisconsin Press, Madison. xxv + 470 pp., illus. U.S.\$17.50.

This volume is a must for all wildlife researchers and managers working with habitat evaluation models. It contains 80 papers describing a variety of practical modelling techniques. The book is divided into five technical sections and one synopsis. Each section contains a number of erudite papers and includes a comment from a manager and a researcher on the applicability of the models to their areas of interest.

In part 1, which contains 23 papers, the authors examine the concepts and issues related to the development, testing, and application of models. Single and multi-species models are presented; a number of authors examine the assumptions associated with models and endeavour to identify methods to test and evaluate them. Of note is a paper by R. A. Lancia, D. A. Adams, and E. M. Lank entitled "Temporal and spatial aspects of species-habitat models". The authors used a temporal model to predict the impacts of a proposed peat-mining operation and spatial models to assess habitat quality for three wildlife species.

The six papers in part 2 focus on some of the biometric approaches used to construct models. Various statistical procedures are presented as

examples of methods with which researchers and managers can develop species-habitat models. Many of the authors review the assumptions associated with the statistical methods employed and how well specific models meet those assumptions. For example, in a paper entitled "Assumptions and design of regression experiments: the importance of lack-of-fit testing", J. M. Marzluff presents an experimental design tailored for regression analyses of avian habitat relations. Marzluff suggests that this approach is applicable to all correlation-based multivariate procedures.

Part 3 contains eight papers in which the authors examine why wildlife habitat can fail as a predictor of populations. Some populations are so strongly influenced by a complex array of factors (e.g. weather, disease, and/or competition) that the relationship with habitat is masked or distorted. Managers and researchers are encouraged to learn to recognize occasions when the distribution and abundance of wildlife populations are being influenced by something other than habitat. An excellent paper in this section is authored by B. Diehl and is entitled "Factors confounding predictions of bird abundance from habitat data". In this paper, bird community dynamics in a changing, heterogeneous environment are examined in the context of a 21-year study.

The nine papers in part 4 focus on techniques which can be employed to identify and predict the effects of habitat fragmentation and patchiness on wildlife populations. The paper by D. L. Urban and H. H. Shugart, Jr., entitled "Avian demography in mosaic landscapes: modeling paradigm and preliminary results" exemplifies the papers in this section. Urban and Shugart pursued a mechanistic explanation for the local extinction of some bird species from small and/or isolated patches in a habitat mosaic. The model was developed to simulate demographic processes of natality, dispersal and mortality. The papers in this section are of particular interest to managers involved with issues relating to the shape and size of the habitats.

Part 5 contains 12 papers devoted to the integration of wildlife models with vegetation succession models. Many agencies are at present engaged in work designed to assist managers in their efforts to make long-term forecasts about the effects of major land-use programs on wildlife. Major issues addressed by the authors include assumptions, accuracy, cost-effectiveness, current status of testing and application, and the suitability of various models. For example G. L. Benson and W. F. Landenslayer, Jr., present a

paper entitled "DYNAST: simulating wildlife responses to forest management strategies". They employed a computer simulation model to evaluate the effects of alternative timber management strategies in the Sierra Nevada area of California.

The synopsis contains a paper by H. Salwasser, who presents the manager's viewpoint, and a paper by H. H. Shugart and D. L. Urban, who present the researcher's viewpoint on modelling habitat relationships of terrestrial vertebrates. These papers are insightful and provide the reader with a focused summary on the applicability of models to research and management.

The book contains graphs, tables, maps, references, and an index. It is highly recommended to all researchers and managers involved in modelling wildlife-habitat relationships. In addition, I feel this book would be very useful to university students because a number of papers demonstrate how ecological theory can be applied in the real world.

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Eskimo Curlew: A Vanishing Species?

By J. B. Gollop, T. W. Barry, and E. H. Iversen. 1986. Saskatchewan Natural History Society Special Publication No. 17, Regina. 160 pp., illus. Paper \$9.00.

Once upon a time the Eskimo Curlew (*Numenius borealis*) was an abundant migrant in North America. Many early ornithologists remarked upon the tameness and fatness of this shorebird, seen in company with migrating Lesser Golden Plovers (*Pluvialis dominica*). By the early 20th century the number of Eskimo Curlews observed diminished; sightings became sporadic, raising fears about the eventual extinction of this species. Indeed, by the middle of the century each sighting became such a noteworthy event that in his 1951 *Audubon Water Bird Guide* Richard Pough suggested that *every* one of them should be published.

In spite of the obvious concern of the ornithological community, there were no plans to study the life history of this species in order to isolate the factors responsible for its virtual disappearance. Instead of scientists, it was Fred Bodsworth, noted Canadian author and conservationist, who publicized the plight of this bird. His hauntingly beautiful book *The Last of the Curlews* (1954), went through numerous printings

and editions, and formed the basis of a Hanna-Barbera animated television special. Though both the book and the animated film raised public awareness, they failed to precipitate any major scientific study.

Hopes for the future of the Eskimo Curlew were rekindled in the 1970s when a number of well-documented sightings occurred. In Canada, J. B. Gollop and C. E. P. Shier prepared a status report, summarizing "recent" (1930-76) sightings of this elusive, threatened bird for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). During the 1970s Eve Iversen of California also began to write a report on the curlew. The present volume, prepared with the extensive help of Mary D. Gilliland, differs in format from all previous efforts. It is also much larger in scope. A vast amount of information on the status and distribution had been culled from hundreds of books, papers, and reports. As the authors state, the "book is an attempt to compile the Eskimo Curlew's history and what is known about its biology largely in the words of people who were its contemporaries" (p. 12). They have been eminently successful.

The book starts with a brief discussion of the current status of this species and presents a table of all

reported Eskimo Curlew sightings during the 1945–85 period. This is followed by an illustrated section on “field identification.” Photographs and pencil drawings of the Eskimo and Little curlews and the larger Whimbrel, together with a table summarizing physical characteristics of these three potentially confusing species, greatly enhance the usefulness of this chapter. Two short historical sections follow: a list of scientific and common names, and “Two nest searches . . . — a century apart.” The bird’s biology is discussed in “Life History — Briefly Stated.”

Much of the book consists of quotes and dates compiled from numerous sources. These range from late 18th-century Canadian observers — George Cartwright in Labrador, and Samuel Hearne and Andrew Graham in what is now Manitoba — to several reports of birds seen in the 1980s at such widely separated locations as Galveston Bay, Texas (23 birds in 1981), and Regina, Saskatchewan (one bird in 1982).

“The Eskimo Curlew’s Year” follows the bird’s path of yesteryear from its known breeding ground in the Northwest Territories through well-documented staging areas in fall migration (Alaska, Ungava, Labrador, Quebec, the Maritime Provinces, and New England) to its wintering grounds in South America. Inland regions, visited during both spring and fall migration, include the provinces of Ontario and Manitoba and eight North American states.

Sightings on various West Indian islands and in parts of South America are grouped under the subheading of “Oceanic Migrations”. There are few winter records: from Chile, Uruguay, Argentina, and the Falkland and Galapagos islands. In comparison with the numerous fall records, spring records are incomplete, and the authors warn the reader that the “route of the curlew’s northward flight from Argentina to Texas is the greatest void in our knowledge of its range” (p. 91).

This slim volume contains an impressive amount of carefully researched information. In addition to the above mentioned sections, there are five appendices and an extensive list (32 pages) of references. There are also a number of welcome illustrations of the bird and its habitat. Several useful maps show the Eskimo Curlew’s migration routes together with breeding and potential wintering areas.

A word of warning: the large amount of information contained in this book makes it somewhat difficult to read. In many sections it is obvious that the book was “compiled” rather than written. Nevertheless, I highly recommend this valuable reference book to all concerned naturalists.

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Blackbirds of the Americas

By Gordon H. Orians, with drawings by Tony Angell. 1985. University of Washington Press, Seattle. 163 pp., illus. U.S.\$24.95.

Ornithologists and birdwatchers know that “blackbirds” are not always black and can at times be very colourful. “Blackbirds” is a general term used to designate the members of the subfamily Icterinae (treated in the present book as the family Icteridae), which is restricted in its distribution to the Americas. It comprises 94 species which range from tree line in North America south to Tierra del Fuego in South America. This very diversified subfamily includes species such as the Bobolink, the meadowlarks, the orioles, the cowbirds, the grackles, the oropendolas, and the caciques, to name only a few.

This book, in addition to a short preface and introduction, contains 12 chapters packed with information which will serve the requirements of ornithologists and ornithology students as well as

those of birdwatchers. In an informative and easy-to-read text the author covers such subjects as the classification, diversity, and origin of blackbirds, foraging and feeding behaviour, nesting, role of the sexes, flocking behaviour, parasitism, communication, physiology, song, and economic aspects.

All these topics are expertly treated and well documented. The text is clear, precise, and easy to read, to the extent that even if one is looking for a particular piece of information, it is difficult to stop one’s reading after the information has been found. The author has succeeded in communicating his vast knowledge of “blackbirds” in an interesting fashion. I am convinced that those who will read this book will never look at “blackbirds” in the same manner in the future. The two appendices summarize a vast amount of information that is not available unless one can scan a large number of references which would exceed by far the list given at the end of the book.

The black-and-white drawings by Tony Angell are of great quality and illustrate well the points made in the book. The printing, layout, and binding are outstanding. Both the author and the artist deserve congratulations for this excellent work which should

be in the library of any person seriously interested in birds.

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A Natural History of Digges Sound

By A. J. Gaston, D. K. Cairns, R. D. Elliot, and D. G. Noble. 1985. Report Series No. 46. Canadian Wildlife Service, Ottawa. 63 pp., illus. \$8.00 in Canada; \$9.60 elsewhere.

Digges Sound lies at the junction of Hudson Bay and Hudson Strait. A Canadian Wildlife Service team studied the large seabird colonies on the Digges Islands and adjacent mainland from 1979 to 1982. These colonies are a conspicuous part of the regional marine and terrestrial ecosystems. Thick-billed Murres dominate the colonies, but several other species are of particular interest because they are at the limits of their ranges. Here, the Iceland Gull is at the southwestern limit of its range, while the Atlantic Puffin and Razorbill are at the northwestern limits of their ranges in Canada. Glaucous and Herring gulls, Black Guillemots, and Arctic Terns also breed at or near the main colonies.

While the CWS team concentrated on seabirds, in particular the murres, they did not limit their investigations to these. The report by Gaston and his associates is indeed a natural history in the traditional sense, and offers a compendium of diverse observations on the flora, fauna, and landscape. They also present a substantial set of detailed data on seabird populations, breeding biology and diet, together with data on the impact of predators on the colonies.

Among the more interesting results of the study was that the low diversity of these colonies compared to High

Arctic colonies, illustrated by the complete absence of Northern Fulmars and Black-legged Kittiwakes, remained inexplicable, despite the apparent availability of suitable feeding areas, prey and nesting sites. The results highlight how little the physical and biological oceanography of Hudson Bay has been studied. This suggests a substantial gap in Canada's ability to understand and manage its coastal waters. It is also unfortunate that the link between research on marine birds and more general marine ecology remains tenuous, in spite of the strenuous efforts of some people. Nevertheless, a useful contribution to information on the distribution of marine organisms of the area is made in this report. By inference from the observations on the distribution of birds at sea, one gains a feel for where concentrations of these organisms may occur.

The report is largely free of errors, apart from some omissions and inconsistencies in the references. The text is relaxed yet informative. There are numerous illustrations, with a couple of quite stunning photographs. Even those with only a passing interest in the intricacies of the lives of murres may find this a diverting account of a beautiful and rather remote part of the country.

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Biology of the Arctic Charr: Proceedings of the International Symposium on Arctic Charr

Edited by Lionel Johnson and Bonnie Burns. 1985. University of Manitoba Press, Winnipeg. 584 pp. \$60.00.

The Arctic Charr occupies a large range in Canada and reaches about 4000 km from north to south between the northern tip of Ellesmere Island and New Brunswick and covers over 3000 km from west to east between Alaska and Greenland. Since the Arctic Charr is a wide-ranging species of interest as a sport fish, a local source of food, and an item of commerce,

the biology of this fish is of great importance to Canada. This book brings together 43 studies on the Arctic Charr and its relatives in Canada, Iceland, Scotland, England, West Germany, Switzerland, Austria and Norway — the result of the International Symposium on Arctic Charr held in Winnipeg, 4–8 May 1981, on the campus of the University of Manitoba.

There are too many papers to comment on in the available space, so I will select a sample. R. J. Behnke

discusses taxonomy of the subgenus *Salvelinus* which he divides into the Dolly Varden complex (it includes *S. leucomaenis*, *S. confluentus*, *S. albus* and *S. malma*), and the Arctic Charr complex. Contrary to K. A. Savvaitova, he finds no evidence of intermediacy or hybridization between the Dolly Varden and Arctic Charr, and this is now supported by the recent studies of I. A. Chereshev. Behnke names his northern form of Dolly Varden *S. m. malma*. This form ranges in North America from the Alaska Peninsula to the Mackenzie River, while the southern form is called *S. m. lordi*, and a third subspecies which ranges from Honshu to south of the Amur River is called *S. m. krascheninnikovi*. He divides the Arctic Charr in North America into a western (Bristol Bay to Gulf of Alaska) form, an eastern Arctic form, and an Atlantic form (New England and southern Quebec) that is recognized as *S. alpinus oquassa*. Behnke performs a valuable service in providing diagnoses to and ranges of species, however brief, and in attempting to find the earliest names for each taxon (though without dates). A comparative character table would have been useful.

Nyman reviews the management of allopatric and sympatric populations of land-locked Arctic Charr in Sweden. He emphasizes the importance of taxonomic analysis in enabling effective management. Swedish authors have examined over 25 000 charr samples from hundreds of lakes using life history, electrophoretic, and morphological approaches. An adequately supported similar project is needed in Canada where we are not yet even sure how far the Dolly Varden ranges east in Arctic Canada.

Based on study of blood serum esterases, Klemetsen recognizes three different population groups of Arctic Charr in Norway, and Gydemo similarly found three groups in Iceland. They believed that these corresponded to Nyman's three sibling charr species. However, two distinct spawning groups of charrs from Bear Island could not be separated by serum esterase analysis. Clearly, Arctic Charr taxonomy calls for more than a single diagnostic tool.

A paper by Eugene Balon reminds scientists that they should not consider speciation solely as the action of selection on isolated characters in the adult stage. Altricial and precocial dynamic states may operate continuously in ontogeny. The process of juvenilization may reverse specialization and may permit survival instead of extinction of a stock. He reinterprets "dwarf" and "normal", sunapee and anadromous *Salvelinus alpinus*, Lake Charr and Siscowet, and brook and aurora *Salvelinus fontinalis* as altricial and precocial pairs. Ali and Klyne view the Arctic Charr through its visual system. They consider

that the Arctic Charr has adapted to seasonally very short and very long day lengths and to shallow and deep water through flexibility in rhythmic retinal patterns, rather than specific retinal structures. Selection of a different type was studied by Jensen, who found that gillnet selectivity on Brown Trout, Arctic Charr and whitefish seemed quite comparable: each was more dependent on the condition of the fish than on the species.

Dick studied the value of parasites as biological tags in the management of Arctic Charr. He found they may be of use in some populations to distinguish sea-run from non-anadromous populations but cautions that variance in distribution of parasites requires the tags to be evaluated for each drainage system. Black reports on using *Cystidicola* species as tags marking dispersal of their charr hosts from different glacial refugia and reported on a field study on the biology of *C. cristivomeri*.

Cavender reports that *Salvelinus fontinalis*, *S. namaycush* and *S. leucomaenis* possess a primitive karyotype for *Salvelinus*, while *S. confluentus*, *S. malma*, and *S. alpinus* possess a derived karyotype. Karyotype differences are found between *S. confluentus* and *S. malma* and confirm the distinctness of these two species, but karyotypes of the latter and *S. alpinus* are close. The differences between the southern and northern form of Dolly Varden suggests that they may differ at the species level and that the northern Dolly Varden may have a sister relationship with the Arctic Charr.

Historically, eutrophication in Lake Constance was found by Hartmann to yield an initial increase and then a decrease in yield. Milbrink and Holmgren found that artificial fertilization could be used to increase production of zooplankton and stream bottom fauna and promotion of Arctic Charr. Other historical studies include a 400-year survey on the Lake Windermere charr fishery in England by Kipling and the Inuit Arctic Charr fishery in northern Labrador by Ledrew.

The convenors, editors and participants of the charr symposium are to be highly complimented on producing an intellectually exciting and very informative book on charrs. The reader will learn much, but there is yet much to be learned on this widespread, highly adaptable complex. I wholeheartedly recommend it to all who work with charrs.

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Otters: Ecology and Conservation

By C. F. Mason and S. M. MacDonald. 1986. Cambridge University Press, Cambridge. vii + 250 pp., illus. U.S.\$34.50.

The title of this volume is somewhat misleading to North Americans because three-quarters of the book deals with *Lutra lutra*, the European Otter. Other species of otter, including *Lutra canadensis*, the Canadian Otter, are dealt with in a somewhat cursory manner in the final chapter. Primarily, the book is about the biology, ecology, and plight of the European Otter as it disappears from a rapidly increasing number of river systems of Europe and Asia. The authors argue for protection and conservation of otters as indicators of health of wetland ecosystems. This species has come to represent a symbol of commitment to conservation by some European agencies.

There are six chapters: a short introduction, four chapters dealing exclusively with *Lutra lutra* and discussing its biology, distribution and status, the factors affecting its survival, and efforts at conservation, and a sixth chapter which covers the biology and status of eight other *Lutra* species, three *Aonyx* otters (two from Africa and one in Malaysia), *Enhydra lutris*, the Sea Otter, and *Pteronura brasiliensis*, the Giant Otter of South America. Written for the educated non-specialist, this book will not offend the mustelid biologist in the least. The authors have done a good job of marrying the scientific literature with a more popular style of writing. A number of black-and-white photographs measurably aid the presentation of data, especially with respect to habitat.

Many aspects of the biology of European Otters remain unknown, primarily because no long-term studies have been done. Much recent work has been mission-oriented and has been stimulated by declining numbers, questions about reasons for declines and, specifically, about the role of pollution. The authors conclude in chapter 4 that pollutants have both directly and indirectly resulted in a sudden and drastic reduction in otter numbers over most of Europe. A second culprit has been the reduction of habitat through removal of cover along streams and channelization of waterways for farming. Otters are in

trouble in the British Isles, France, Italy, Spain, Benelux, West Germany, Japan and Denmark. Good sized populations continue to exist in Norway and Sweden. However, over much of its range few data on population status exist. Legislative protection has been slow in coming, and, despite obvious declines in otters, hunting lobbies and lack of co-operation from eel fishermen (in whose nets otters often drown) have impeded legal protection. This is of course a familiar story to anyone working to preserve wildlife the world over.

It is interesting to contrast the European concern for their otter with the virtual disinterest in otters, and indeed other furbearers, in this country. Of the many species of small Canadian carnivores, only Ermine (*Mustela erminea*), Marten (*Martes americana*), Red Fox (*Vulpes vulpes*), Arctic Fox (*V. lagopus*), and Lynx (*Lynx canadensis*) have been the subjects of intensive study. In fact, Mason and MacDonald chide North American agencies for not taking advantage of the numerous carcasses discarded each year by trappers as a source of biological information as well as background data on levels of pollutants. However, in all fairness, it must be pointed out that British interest was only translated into research funds once a precipitous decline in otters had occurred.

The final chapter is a discussion of other otters of the world and includes range maps for each. The authors make a commendable effort to summarize present knowledge (or lack thereof). There is a heuristic value in comparing species differences. For example, although Canadian and European otters have much in common, delayed implantation is only shown by the former. Does this then imply different ancestors with converging evolutionary paths?

In conclusion, I found this book to be well-researched, well-written, and interesting to read. I recommend it highly. It is unfortunate that it relates yet another sad tale of human lack of caring for the creatures which also share the planet.

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The Bald Eagle in Canada: Proceedings of Bald Eagle Days, 1983

Edited by J. M. Gerrard and T. N. Ingram. 1985. White Horse Plains Publishers, Headingley, Manitoba, and the Eagle Foundation, Box 155, Apple River, Illinois. viii + 272 pp., illus. U.S.\$20.00.

The first Bald Eagle Days Conference, held in Wisconsin in 1967, had as its purpose the stimulation of public interest in problems facing the national symbol of the United States. The 1983 conference, held in Winnipeg, had as its major theme the status of bald eagles in Canada, and was the first attempt to assemble population information, particularly on nesting status, for the whole country.

The proceedings are arranged in four major sections. The first (three papers) deals with the work of Charles Broley, a Winnipeg banker who pioneered the study of bald eagles after his retirement at age 58, and who died in 1959. The 1983 conference was held in Winnipeg in his honour and the proceedings are dedicated to his memory. Canada needs heroes and Broley should be high on the list. He climbed to hundreds of nests in Florida and Ontario, banded over 1200 eagles, and was the first to document dramatic declines in nesting success after the Second World War. As U.S. researcher Doris Mager notes in her paper on Broley's work in Florida, "It is not well known . . . that a retired banker in his 70's, from Canada, almost single-handedly charted the course for the recovery of the national symbol of the United States — the southern Bald Eagle."

The second section contains status reports for eight provinces. Notably lacking are Alberta, Quebec, and the Territories. Reports are mostly brief and to the point but, as might be expected, survey intensity, completeness, and reliability of results vary considerably from province to province. They indicate that, except for southern Ontario where Bald Eagles were reduced to virtual extirpation, Canadian eagles are doing well. Estimated number of adults present in the breeding season vary from 15 000 in

British Columbia to fewer than 10 in Prince Edward Island.

The following two sections contain seven papers which were peer-reviewed and 12 which were not. The editors were wise to make this distinction. Several papers deal with actual or potential impacts of human activities on Bald Eagles, including forest harvesting, hydroelectric flooding, recreational cottage development, commercial fishing, acid rain, and research disturbance. An excellent paper by James Fraser reviews several such impacts and gives the impression that all is not well. Other papers address behaviour, census techniques, habitat management initiatives (all too few), and public involvement in eagle conservation programs. Workshops on field-sexing Bald Eagles and on reintroductions, and three miscellaneous abstracts, complete the volume.

The collection of papers suggests some encouraging trends with respect to Bald Eagle management and conservation, including more extensive inventory programs, increased emphasis on ecological pathways leading to Bald Eagles (e.g. effects of acid rain and of commercial fishing on eagle foods), the emergence of innovative and successful programs of public involvement (e.g. the "Eagle Beagles" in Arizona), and translocations within and between the U.S. and Canada. In recent years Bald Eagles have been reintroduced to former breeding habitats at Long Point, Ontario, and to parts of New Jersey, Massachusetts, Pennsylvania, the Adirondacks, and California.

This volume is a must for anyone seriously interested in Bald Eagles, and is recommended to those interested in pioneer conservationists.

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Fishes of the North-eastern Atlantic and the Mediterranean/ Poissons de l'Atlantique du Nord-Est et de la Méditerranée

By P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen, and E. Tortonese. 1986. UNESCO, Paris. Volume II, pp. 507–1007, illus.

The second volume of this series covers the orders Cetomimiformes, Saccopharyngiformes, Halosauriformes, Beloniformes, Cyprinodontiformes, Syngnathiformes, Gasterosteiformes, Gadiformes, Lambriformes, Beryciformes, Zeiformes, and the Perciformes up to the family Xiphiidae. Ninety-seven families are discussed and include the following well-known or speciose families: eels — Anguillidae, cods — Gadidae, seabasses — Serranidae, jacks — Carangidae, drums — Sciaenidae, and the mackerels — Scombridae. Volume III will cover the remaining fishes. The book contains a table of contents for each of the three volumes, and family, generic and species-group accounts. There is no index, which will presumably be provided in the last volume.

In this volume there are keys to the species under the family account (the key to families was contained in the first volume). Species accounts contain the current name, common synonyms, the common name, a description, a statement of habitat, and distribution. There is a line drawing and a distribution map for most species. For further details on format see the review of volume I (McAllister and Coad. 1986. Canadian Field-Naturalist 100(1): 152–153).

Pungitius platygaster is treated as a separate species from *Pungitius pungitius*, rather than as a subspecies. Three subspecies are recognized in Europe for *Gadus morhua* but *G. m. kildinensis* Derjugin from Kildin Island, Barents Sea, is either omitted or considered a synonym of one of the other subspecies.

The drawings originate from several sources and artists, but the resulting variety is not displeasing and

does not interfere with their utility. However, the drawings for *Hymenocephalus gracilis* and *Malacocephalus laevis* are too dark. Detailed anatomical characters are used with good effect to show diagnostic characters in some families, e.g. teeth and branchiostegals in Serrivomeridae, otoliths and gas bladders in Scianidae, and scutes in Carangidae. A few more would have been worthwhile.

The distribution maps use triangular spots, dark bands along the shorelines, or diagonal shading to indicate the ranges of species. A standard European base map is used; this facilitates comparison of ranges. The maps are placed on the right-hand third of the page. Where the text of the species account is longer than the map is high, the column above the map is left blank. If the text had been continued to the right into the blank area savings of 5 or 10% in the length of the book might have been made. However, the overall design of the book is pleasing and functional.

This book provides succinct descriptive, distributional, and biological information on the fishes of Europe. Many of the families and genera and some of the species are the same as those in North America, so that if the reader is interested in fishes of Europe or in broader aspects of some North American species, this is a worthwhile reference book to have. The book is well designed, printed and edited. The editorial committee is to be complimented on their high standards, and the authors, on their contributions.

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The Inland Fishes of New York State

By C. Lavett Smith. 1985. The New York State Department of Environmental Conservation, Albany, New York. 522 pp., illus. U.S.\$29.95.

This large (22 × 29 cm) book covers all the inland fishes known to enter the freshwaters of New York state, an area of some 130,000 km². It includes 167 freshwater and diadromous species and 75 marine species known in the estuary of Hudson River. The book is intended to provide a list of the inland fishes of the state, to provide a means of identifying juveniles and adults, and to provide summaries of life history and ecology with an introduction to the literature.

The book includes a preface and nine major sections: 1) "Ichthyology in New York" — a knowledgeable historical review; 2) "The State of New York" — a summary of climate, land forms, watersheds and habitats; 3) "The New York fish fauna" — a treatment of origin and age of the fauna, distribution patterns, geology, stream capture, and influence of man; 4) "How to use this book" — more about how it was made, viz. maps from 1975 to 1982 from the American Museum of Natural History and other museum records, the literature, and the New York State Conservation Department Survey (this

section also includes material on the classification used, counting and measuring methods, and notes on how to identify fishes); 5) "Freshwater and diadromous fishes of New York" — discussed below; 6) "Marine fishes in the inland waters of New York"; 7) Glossary; 8) References — 40 pages of references (including not one by C. L. Smith); and 9) Indexes — the author made, in my view, an unhappy decision to include four indexes — alphabetical serials (periodicals), common and scientific names, geographical names, and subjects. The reader must first find the right index before beginning his/her search; I would suggest combining the indexes for the second edition or at least moving the first name index, the most used, to the end. Two-part common names are entered in the index under the normal and inverted sequence, but scientific binomials only under the normal sequence.

Sections 5 and 6 start with an illustrated multi-character key to the families. Each family is introduced by a family account, often illustrated and about a page long, which describes the family, enumerates the species, and comments on their identification and economic value. The minnow family account shows how to remove pharyngeal teeth for identification purposes. The family account is followed by an illustrated key to the species and by generic and species accounts. Each species account contains the following sections: Accepted common and scientific names; Identification — diagnostic features; Description — including shape, meristic and morphometric characters, and color; Habitat; Distribution — world and New York; Life history; Food and feeding; Notes — on relationships or taxonomic problems; References — authors and dates of important references; and Names — origin of the scientific names. Most species are accompanied by a spot distribution map for New York.

The text uses simple words in preference to technical ones. This will make it more useable for the amateur, while use of scientific names alone in comparative tables of diagnostic characters will be less understandable for the average reader. An occasional table, e.g. Table 6, has an unrealistically small specimen compared with large ones of other species. In a few of the maps the spots or circles are too small to be easily seen. A number of Smith's maps have records not in the *Atlas of North American freshwater fishes*; these records fill in ranges or

extended them slightly, but a few Atlas records are apparently missing from *Inland fishes of New York*. Range statements are generally accurate but we are told that *Myoxocephalus thompsoni* and *M. Quadricornis* co-occur in James Bay; in reality, only the latter is known in James Bay.

Of interest to Canadians is the close occurrence of the Margined Madtom, *Noturus insignis*, in western New York, only 130 km from the Canadian record in the Gattineau basin. The closeness of the New York record makes it plausible that the Canadian occurrence is natural and not due to introductions. Smith is aware of potentially occurring species; he mentions, for example, the characters of the Copper Redhorse, *Moxostoma hubbsi*, so that the reader can check for possible New York records of this species. *Rhinichthys meleagris* is treated as a distinct species instead of as a subspecies of *R. atratulus*, but the two ranges are not distinguished on the distribution map. Solid circles on the maps indicate records collected by the American Museum of Natural History from 1975 to 1982; open circles generally indicate collections by earlier workers. Sadly, as in studies elsewhere in the U.S. and Canada, these maps suggest that the ranges of many species — e.g. Kiyi, Brassy Minnow, Swallowtail Shiner, Redside Dace, Brook Silverside, Iowa Darter, and Pirate perch — have shrunk in New York.

Drawings are presented for most species both in the text and in the keys; this is a useful duplication. Most drawings, although not highly detailed, are sufficient to aid in identification. They depict the "feel" of the fishes and are knowledgeably done. However, the Emerald Shiner is shown as too stout, in my view, and the mouth of *Phoxinus* spp. is poorly drawn. The colour plates are pleasing.

This is a carefully written book by a knowledgeable ichthyologist. It achieves more than its goals and provides a large amount of useful information on New York inland fishes. It is recommended to Canadians living in Quebec and Ontario; the two provinces which border on the State of New York. The author is to be commended for an excellent job.

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BOTANY

Plant Biosystematics

Edited by William F. Grant. 1984. Academic Press (Harcourt Brace Jovanovich, Toronto). xv + 674 pp., illus. \$64.50.

In July 1983 the International Organization of Plant Biosystematists met in Montreal, 40 years after the term "biosystematy" was introduced by W. H. Camp and C. L. Gilly. Biosystematics involves the acquisition and incorporation of knowledge on all aspects of the biology of organisms into a classification system. Thus, the methods of traditional taxonomy have been combined with those of cytology, genetics, population biology, ecology, chemistry, physiology and biogeography. This volume constitutes the proceedings of that symposium. Thirty-eight papers, covering all of the subdisciplines of biosystematics, comprise the text.

The contributions in this book are grouped on the basis of general subdisciplines. Within each grouping, a series of papers discuss the types of information that can be obtained from plants, and how these data can contribute to an understanding of the evolutionary processes and to the classification of the study group. Seven papers deal with various aspects of cytology and cytogenetics. These include examples of the use of the karyotype, chromosome banding patterns, chromosome pairing relationships and behavior, DNA content and variation, and ploidy level in a wide variety of plants from around the world. The second section ("Breeding systems and hybridization") examines species concepts and the importance of hybridization. The section on plant reproduction and reproductive isolation provides reviews of plant reproductive strategies and a review of the modes and implications of pollination by animals. Eight papers discuss the application of various techniques to systematic problems. Phenotypic plasticity and its analysis and significance, the application of biogeographic, cytological, morphological, anatomical, phytochemical, and palynological data, an examination of ribosomal DNA variation in *Claytonia*, isozyme evidence and its varied uses in biosystematics, numerical taxonomy, and the problems imposed by hybrids on the assessment of evolutionary history are all discussed and related to "difficult" groups.

Population-based studies form an integral part of biosystematics and several papers devoted specifically to that focus are included. Experimental approaches to population biology (life history features, genetic structure of populations) are discussed in relation to closely related annual *Lupinus* species. The use of cytogeography (the distribution of chromosome

racces) in the study of evolution is reviewed (particularly with European examples). The relationships among closely related endemics in Macaronesia (Azores, Madeira, Salvage, Canary, and Cape Verde islands) are examined using experimental hybridization and the analysis of natural hybrid swarms. The processes leading to speciation on these islands include changes in basic chromosome number, chromosomal re-patterning, hybridization, and ecogeographical isolation. The problems of conducting biosystematic investigations on rare tropical forest plants are also discussed in this section. There are two papers devoted to the biosystematics of cryptogams.

A section on "Biosystematics and its practical implications" will probably be of interest to the widest audience. The first paper in this section, "Biosystematics and medicine", deals with the properties of plants that may assist in medical developments. The knowledge of chemical diversity that can be obtained by biosystematists can assist pharmaceutical chemists in their quest for new and improved drugs. Several papers deal with the modes of evolution in domesticated plants (fruit and vegetable crops, grains and horticultural cultivars) and the implications of the type of selection on the maintenance of variability in such plants.

The application of biosystematic knowledge to conservation issues is also discussed. The importance of knowledge about population structure, floral biology, dispersal, interactions with other species, abiotic requirements, and all aspects of the life history strategies of rare plants in making management decisions is emphasized. Far more emphasis must be placed on biosystematic studies in the poorly known tropical regions, where the dangers of decimation and extinction are most pressing.

The volume concludes with two overviews: one deals with various categories that have been used to label levels or types of variation in plants, and how to incorporate biosystematic evidence into classification schemes; the other provides a summary of the advances made in biosystematics with the incorporation of a wide array of methodologies. However, it is becoming increasingly difficult for an individual systematist to be competent in all of the subdisciplines that have a bearing on the field. It is becoming more and more necessary to work in collaboration with others who have complementary skills to solve the problems with which we are faced.

It is difficult to provide a comprehensive review of a volume that is loaded with such a wide array of information from so many different subdisciplines.

However, my general impression is that the volume gives a good indication of the theoretical and practical considerations that go into modern biosystematic studies. The only area which receives limited attention in this book is the reconstruction of evolutionary history. Phipps' paper on hybrids in *Crataegus* addresses this issue directly, and other papers discuss evolutionary relationships of various taxa, but the incorporation of biosystematic data into the generation of phylogenetic trees could have been more fully exploited. In general, the quality of the papers is good, but the grammar is rough in places (undoubtedly due to translation problems). Many of the papers are well illustrated, and all include many useful references.

The most disturbing aspect of the book does not relate to its content *per se*, but severe criticism of its production is warranted. It was produced from camera-ready copy, presumably to minimize the time between the symposium and the appearance of its proceedings. As a result, hasty typing and extremely poor proof-reading have led to a host of typographical errors. In most cases, these errors do not interfere with the interpretation of the text. However, in a few places (e.g., p. 418) it was necessary to work through

paragraphs to determine what was being said, not because the paper was poorly written, but because parts of paragraphs were duplicated and inserted in the middle of other paragraphs during the typing process. In one place (p. 519), the photographer missed a part of a page. These kinds of errors should not occur. In this case, the additional time spent on proofing would have compensated for a short delay in production.

Although the book is too technical for most to read from cover to cover, it contains many papers that will be useful to people interested in specific groups or specific types of biological problems. All institutional libraries should acquire this book, and all biosystematists should read it. I might also suggest that it could serve as a useful text for an advanced undergraduate or graduate course in plant systematics. Animal systematists would also do well to read this book to gain an insight into the problems and approaches used in botanical systematics.

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A Field Manual of the Ferns and Fern Allies of the United States and Canada

By David B. Lellinger. 1985. Smithsonian Institution Press, Washington. ix + 389 pp., illus. Cloth U.S.\$45; paper U.S.\$29.95.

It has been many years since a treatment of North American pteridophytes has been produced. With the tremendous changes in fern taxonomy and nomenclature in recent years the need for such a text has been great. This book is intended to provide that up-to-date review of all fern and fern allies known in Canada and the United States (excluding Hawaii). It is also meant to be technically accurate and complete while appealing to a wide range of professional and non-professional botanists.

It starts off very well. The introductory sections on fern taxonomy, classification, structure, and life style, as well as fern culture and the human uses of pteridophytes, are excellent. Of these, the discussions on collecting, pteridophyte classification and morphology are particularly clear and useful. The tone of the text is discursive and readable — clearly intended not to discourage the novice. It achieves this without a loss in accuracy or understanding. Production quality is good, with clear, readable type and a well bound volume being published on good quality paper.

The keys to families, genera, and species are critical to the success of any floristic manual. With this book they are at once a strength and a weakness. On the one hand, an innovative reference system that ties key couplets together allows the reader to work back through the key — a super feature. On the other, though, the characters used in the keys are very limited and describe only the most typical morphological features, many of which are not absolutes in any case. While these distinctions seem clear enough in the manual, they are seldom so cut and dried with real material, especially for complex groups like *Lycopodium*, *Botrychium*, *Selaginella* or *Cystopteris*. I found it only too easy to get off track, even with typical specimens of known material. The *Lycopodium* key is particularly unsatisfactory in this regard. The keys would also have been physically improved by bold face type for species names; they blend into the background in this margin-to-margin printing format.

The species accounts are initiated by reasonably full technical descriptions of the taxon. A brief (one or two line) habitat description follows which in most cases is adequate if not particularly illuminating. As there are no distributions maps, the written range

descriptions are very important. While these are probably satisfactory for United States ranges, they vary from barely adequate to completely incorrect for Canadian distributions. *Lygodium palmatum*, for example, is reported from Ontario — despite the absence of any Canadian records. Similarly, *Thelypteris simulata*, *Woodsia obtusa*, and *Isoetes riparia* are not reported for Ontario, nor is *Lycopodium lucidulum* for Manitoba or *Pellaea atropurpurea* for British Columbia. These are all well documented in Canadian literature. The general nature of the range descriptions can also be misleading; *Woodsia scopulina*, for example is described as “Frequent. Quebec to British Columbia . . .”. While technically true, the species is rare east of the Rocky Mountains, although the reader has no way of knowing this.

My biggest “beef” with this manual is its treatment of nomenclature. Very up-to-date nomenclature is employed and that’s all to the good. Unfortunately, the author includes a bare minimum of synonymous names. I dare say only a handful of botanists could read this and not encounter new names for species they knew by others. *Pellaea occidentalis* (*P. pumila* or, if you prefer, *P. glabella* var. *nana*), and several species of *Isoetes*, *Gymnocarpium* and *Lycopodium* serve as examples of this. I’m sure many readers will end up pencilling in the necessary synonyms for many taxa.

Lellinger has chosen to follow the concepts and conclusions of W. H. Wagner and his associates very closely — witness the vast number of citations to their literature. While no one will question the exceptional expertise of this group, I wonder if the author hasn’t been somewhat slavish in his following of them, to the detriment of other views and expertise. I found the absence of *any* paper for which Donald Britton of the University of Guelph was senior author to be quite astonishing, especially given his important work with

Polypodium, *Dryopteris*, *Gymnocarpium*, and pteridophyte distributions. Absent too was any reference to Lamina Kott’s *Isoetes* studies. Lellinger even chooses to follow Wagner’s older concepts for *Gymnocarpium* in the face of compelling arguments in favour of the treatment by Britton, K. Pryer, and Finnish botanist J. Sarvela. Even the most ardent Canadian nationalist would have found no fault in a great deal more “free trade” in this area!

Other reviews have made much of the photographic section of the manual and I quite agree that the colour photographs of the majority of North American taxa are important and attractive additions to the work. Some errors have been noted (the captions for photographs 388 and 386 and for 399 and 400 should be reversed), but these are minor.

I thoroughly enjoyed Lellinger’s discussion of a number of well known (infamous!?) hybrid complexes complete with schematics of the relationships within them. This really helps to clarify some tricky situations and is a high-point of the manual. Similarly, the illustrated glossary is superb — the best I’ve seen anywhere for pteridophytes.

It’s difficult to make an all-encompassing statement about the success of this book. It is so good in some ways (illustrations, the glossary, discussion of hybrid complexes, introductory section, etc.) and falls rather flat in others (Canadian distribution and literature, synonymy). It is *almost* the “bible” we’d all like to have. I suspect readers will want to have other regional literature to back it up — especially in Canada — and will need more specialized taxonomic literature to make much headway with the tough groups. It is, nonetheless, an interesting and useful review of North American pteridophytes.

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Michigan Flora: A Guide to the Identification and Occurrence of the Native and Naturalized Seed Plants of the State, Part II: Dicots (Saururaceae — Cornaceae)

By Edward G. Voss. 1985. Bulletin 59. Cranbrook Institute of Science and University of Michigan Herbarium, Bloomfield Hills, Michigan. xix + 724 pp., illus. U.S.\$12.50.

The first volume of Michigan Flora, which treated the gymnosperms and monocotyledons, was published in 1972 as bulletin 55 of the Cranbrook Institute of Science. A review of this volume may be found in *The Canadian Field-Naturalist* 87(3): 330 (1973).

The format of this volume is similar to that of Volume I. As in the first volume, there are no detailed descriptions, but there are quite detailed keys to the

genera and species, as well as references, distribution maps, line drawings (for about one third of the species), habitat and distribution information, and most important, the easily flowing notes which tell of associated species, where problems exist in distinguishing associated species, interesting characteristics which help in distinguishing closely related species, and special references to the plants as they occur in Michigan as compared to elsewhere in their ranges.

The introductory material is naturally short because it was not necessary to repeat much of what

was in the introduction to Volume I. However, there is information given on the basis of the flora, criteria for accepting species treated, taxonomy and nomenclature, and references. As an introduction to the Taxonomic Section, there are notes on the keys, scope of Part II, style, illustrations, abbreviations, and symbols.

As indicated in the title, this volume treats the dicotyledons from the Saururaceae to the Cornaceae, that is, those families in which, with few exceptions, the flowers lack petals or in which the petals are separate from one another. Part III will include those families in which the petals are united.

One drawback of this volume is that there are no keys to the families included. Thus, the user who is not too familiar with the families of dicotyledons, has to rely on such descriptive floras as *Gray's Manual of Botany* and the *New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent*

Canada. It is to be hoped that Part III will include such a key when it is published.

Again, as in the previous volume, the value of this book is not restricted to those who live in the State of Michigan. Botanists and naturalists in the surrounding states and in southern Ontario will find the information provided to be invaluable. The easily affordable price should ensure that it will form an important part of most botanists' and naturalists' libraries in that region.

Since Part I was published, it has taken fifteen years to produce this most useful book. One hopes that Part III is already in an advanced stage of writing and that it will be published soon.

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ENVIRONMENT

The Naturalist's Field Journal: A Manual of Instruction Based on a System Established by Joseph Grinnell

By Steven G. Herman. 1986. Buteo Books, Vermillion, South Dakota. 200 pp., illus. U.S.\$14.00.

This book provides a detailed methodology of the late Joseph Grinnell's scheme for recording and maintaining natural history field observations. Author Steven Herman directs this instruction manual on keeping field records primarily towards serious naturalists who think "enough of their work to make a systematic and permanent record of it" and who want to bring "order, precision and accuracy to field observations." Herman has somewhat modified Grinnell's original tripartite technique (Journal, Species Accounts, and Catalog) and has included many pages of sample entries from his own notebooks as a guide to the novice. He strongly encourages naturalists to keep both a daily journal and an annual account of each species. A brief biography of Grinnell, an eminent biologist and naturalist in the Museum of Vertebrate Zoology at the University of California, Berkeley, and a short section of the tradition of the naturalists's journal are also included.

Herman recognizes that as years have passed and modern conveniences such as the typewriter, tape recorder, camera, and computer have increased in importance and use, fewer people will want to sit down at the end of a long, tough day in the field and write out their day's observations. However, he steadfastly claims that Grinnell's system of recording still has much to offer the modern student: developing

observational and organizational skills, encouraging self-discipline, consistency in style and format, and reliability, accuracy and precision, as well as producing a very valuable record of observations.

Steven Herman obviously takes his journal writing very seriously, and his admirable commitment to improving the quality of field journals is very evident in the no-nonsense tone of his writing. Fortunately, he also recognizes the many difficulties inherent in maintaining field records according to the "rigorous" Grinnell System and even offers suggestions for those who have fallen far behind in their recording. He gives potential journalists plenty of helpful advice and much needed encouragement but strikes an unnecessary chord of intolerance with his warning to readers to "Beware the Person Who Takes Poor Notes or None At All". With chapters on equipment, procedures, format and style, what exactly to include in the journal, and what to then do with your information, this is a very practical, "how-to" book. Those of us whose journals do not quite meet the high standards set by the Grinnell System in this book can now use it as a guideline as we continue the battle to bring acceptable order to the chaos of our field observations.

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Computer Models in Environmental Planning

By Steven I. Gordon. 1986. Van Nostrand Reinhold (distributed by Gage, Agincourt, Ontario). 222 pp., illus. \$51.75.

The author's objective is to provide a primer for those who use computer models in environmental planning and impact analysis. This book does not go very deeply into the scientific and mathematical content of the models discussed. Inevitably, some essential equations are used but only to explain or support the discussion. The author, instead, has concentrated on giving the reader a background in the principles involved and has reviewed several major models in a number of different categories. With each model he points out its strengths and weaknesses and shows how it can be used in a decision-making process.

The book is divided into six chapters. The first chapter is a general introduction to the modelling process and it sets the scene for what models can and cannot do. The author shows that computer models are a tool, and like any other tool, can be used and misused. I know of many people who have learned the jargon of computer modelling, but do not yet understand its function. These people would benefit greatly from reading at least this first chapter. The author's attitude to his favorite subject is evident in the following quote: "In some ways, the person hawking computer models should be viewed in the same way as a used car salesman in order to maintain a healthy understanding of what is being purchased."

The second chapter deals with water quality models. There is a brief theoretical overview in which the author introduces several concepts — conservative and non-conservative pollutants, steady state and dynamic models, deterministic and probabilistic models — which perhaps more correctly could have been dealt with in the first chapter. He then discusses two specific water quality models in modest detail and gives a brief description of a third model. Using some typical data he shows how a water quality model can be part of logical decision making.

The third chapter deals with storm water run-off models. Here the author has to give a little more theoretical background, but avoids getting bogged down in mathematics. In this chapter the reader gets a better understanding of some of the difficulties faced in developing and using mathematical models. Much more data are given and there is a more detailed

discussion of the problems and uses of outputs from the examples given.

The remaining chapters follow the same pattern as chapters two and three and cover air pollution models, land capability evaluation, and hazardous waste. The discussion of hazardous wastes includes an introduction to pathways analysis and the complexities of changing chemistry with time. The book also has two appendices. Appendix A deals with the often forgotten but very important problems associated with the transfer of a computer program to the purchaser's equipment. Appendix B is an extensive classified bibliography.

This book is an excellent introduction for those who are beginning to use and become involved with environmental computer models. It is also a valuable reference for individuals who make use of the output of computer models in the decision-making process while not participating in the modelling work itself. It is written in a straightforward, easy-to-read style that avoids the use of unnecessary specialist computer terms.

The book does have a bias: the reference to the U.S. regulatory framework is not entirely compatible with Canadian conditions; the examples used show the author's background is primarily in city and regional planning. The examples are also concerned with the very short term (generally days and weeks). The author does not give much information on the status of models for long-term (years to hundreds of years) systems. This deficiency is reflected in the author's discussion of validation (validation of long-term predictions would warrant a chapter of its own). Neither does the author spend any time on the advantages and problems for probabilistic models (particularly with the interpretation of output). The chapter on hazardous waste is a very brief overview of a complex problem.

This is a useful and easily read book that I heartily recommend to anyone becoming involved with the use of computer models. In particular, I would recommend it to those who do not have direct contact with the modelling process itself and yet are expected to make decisions using its outputs.

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Ecology of Biological Invasions

Edited by R. H. Groves and J. J. Burdon. 1986. Cambridge University Press, Cambridge, ix + 166 pp. Cloth. U.S.\$44.59.

Since the title is very misleading, the book is a disappointment from the start. Far from being a synthesis of the field, it is instead a collection of a dozen papers presented at a 1984 symposium entitled *The Ecology of Biological Invasions in Australia*. It is hard to escape the conclusion that the decision to drop the final two words from the book title was a cynical attempt to increase sales, an attempt that approaches the moral (if not legal) definition of misleading advertising. Perhaps the plan was to recall Charles Elton's 1958 book *The Ecology of Invasions by Animals and Plants*. If so the plan misfires badly. Elton's book is a genuine classic, a masterpiece of synthesis and insight ranging from raw data to what is still among the best discussions of environmental ethics I'm aware of. The present book, by contrast, is just another symposium volume, of narrow scope and variable quality.

The idea for the symposium was a good one, and I'm sure it was successful. It was part of the international SCOPE (Scientific Committee on Problems of the Environment) project on biological invasions. Australia is an obvious place to investigate this topic, for it has a famous history of ecological research and an infamous history of deliberate introductions, many of which are well documented. Acclimatisation societies flourished in the nineteenth century, "freely assisted" as Myers points out "by the British Government and ships' captains, who considered it their patriotic duty to turn Australia into another England". Over two dozen species of foreign birds, including even the ostrich, are now part of the Australian scene, as are large numbers of other vertebrates, invertebrates, plants, and microorganisms. Some, such as the prickly pear cactus and European rabbit, have caused spectacular economic damage. Others have not, but have they affected distinctive ecosystems and species of the continent?

An important generalization, borne out by many of the contributions to this volume, is that introduced species are most successful in disturbed ecosystems. There is an intuitive logic to this, but what is less clear is the reason why the foreign weedy species are more successful than the local weedy species, both here and elsewhere in the world. It is this question which allows

the phenomenon of introduced species to make a contribution to ecosystem theory. Arthington and Mitchell provide some interesting evidence that invaders are successful because they have low levels of predators and pathogens. Unfortunately, few of the other authors even acknowledge the question.

Only a few of the papers are of the standard required by international journals. Gibbs, Meyers and Groves provide useful summaries of microbial, vertebrate, and plant invasions, respectively. Barrett (from the University of Toronto) and Richardson give a very interesting discussion of the genetic attributes of invading species and suggest in passing that water hyacinth is so successful because it is a genuinely better mousetrap, with no real competitors among the native plants. (This suggests to me a parallel with European Frog-bit, a smaller plant of similar growth form now spreading through lakes of eastern Ontario.)

Many of the other papers are less worthy. It is embarrassing to read a discussion based on a time series of only three points, and to be told that the modest difference in slope between the two line segments so defined is full of biological meaning. Elsewhere there is an elaborate word model based on insights such as that foreign fish in Australia are either oviparous, ovoviviparous, or mouth breeders, and either opportunistic predators or omnivorous (except in herbivorous groups, where the trend is less pronounced). The model is undoubtedly correct, but since it seems to apply to the majority of all fish everywhere, its utility is unclear.

A good conference paper does not necessarily make a valuable contribution to the literature. So, although I wish I had been at the conference, I do not intend to have my library order a copy of the book. It is a more expensive, less convenient, and less rigorous way of making ideas available to the scientific community than the established route through journal editors. The scientific publishers have served us well, but that does not mean we must automatically buy everything they try to sell.

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The Evolutionary Ecology of Ant-Plant Mutualisms

By Andrew J. Beattie. 1985. Cambridge University Press, Cambridge, x + 182 pp. Cloth U.S.\$32.50; paper U.S.\$13.95.

Ants are ubiquitous in terrestrial ecosystems. The species living in a single place may be as different in size as a human and a blue whale. They may live in organized societies, keep domestic animals, tend gardens of fungi, and take slaves. They also enter into a whole range of more subtle relationships with plants, and it is these that are reviewed in this readable book.

Since ants can protect plants from insect pests and benefit them in other ways as well, there are some circumstances in which the plants seem to have something to gain (from an evolutionary perspective) in going out of their way to attract ants. There are many examples of plant features that can be interpreted as ant attractants. These include extrafloral nectaries, food bodies produced on bark, and nests or domatia, such as the hollow spines of some acacias. Some workers have even suggested that some plants tolerate infestations of herbivorous homopterans because these in turn attract ants, with the net effects being positive to the plant.

As well as protect plants from enemies, ants also disperse seeds. The seeds of many species are equipped with elaiosomes or fleshy food rewards that appear to encourage this beneficial behaviour. Interestingly, ants are not good pollinators. Beattie explores the theory that ants, being for the most part soil-dwellers, have had to evolve mechanisms for resisting fungal attack, and that these mechanisms function against pollen as well.

The best chapters are those discussing topics that Beattie has worked on himself. In these there are careful discussions and alternative hypothesis confronted by actual data. Some of the other chapters, by contrast, lack this critical, insightful edge. The first warning of this is on the first page: "the origins and early evolution of ant-plant mutualisms are largely matters for speculation, but this has not stopped me from writing most of Chapter 2 on the subject". There is a lot of speculation, most of it fun, but it all comes together by the end of the book.

Realistically, but perhaps surprisingly, the overall conclusion of the book is that "ant assemblages are in large part fortuitous, interaction is diffuse and facultative, and specialization between particular ant and plant species an exceptional occurrence". Similarly, "the overwhelming majority of ant-plant mutualisms involve fortuitous groups or assemblages of ants responding to plant rewards". This conclusion is in keeping with much modern ecological research, which consistently tells us that ecosystems are less clock-like than we once believed.

My only complaint is that, considering the conclusion, the idea of evolved mutualism is rather oversold in the title and elsewhere in the book. Aside from this, I have no reservations in recommending this work to a wide audience.

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Lake Gårdsjön: An Acid Forest Lake and Its Catchment

Edited by F. Andersson and B. Olsson. 1985. Ecological Bulletins No. 37. Publishing House of the Swedish Research Councils, Stockholm. 336 pp., illus. U.S.\$44.00.

The acidification of poorly buffered inland waters is one of the most serious environmental problems of the present day. This book is a collection of papers about a Swedish lake that has suffered particularly badly in this regard.

Lake Gårdsjön is a small lake (area about 30 ha, mean depth about 5 m) which shares its 2-km² catchment with three smaller lakes. The catchment largely consists of shallow podzols lying on bedrock with frequent outcrops, partly covered with coniferous forest. From the description and photographs it seems not unlike many areas of the Canadian shield. The water of the lake is chemically similar to that of shield lakes too, except that it is

relatively high in sodium and chloride because of the nearness of the sea. The book should therefore be of considerable interest to Canadian limnologists.

The papers are grouped by general subject matter (history, water and element cycling, biology, sediments) but are essentially independent of each other. In sum, however, they provide a clear picture of the lake and what has happened to it. Historical records have made it possible to reconstruct the pattern of land use in the catchment over a period of many years, and sedimentological studies have made it possible to follow the course of acidification. It seems clear that while land use changes may have made a minor contribution to acidification, the principal cause has been atmospheric deposition. Fish have been completely eliminated from the lake, perhaps partly on account of increased aluminum

concentrations in the water caused by increased leaching from the soil. The loss of fish has caused shifts in the lake ecosystem as invertebrates have taken over the role of top predators.

The papers in this book are clearly written in excellent English, but they are original reports of research primarily for other specialists in the field and, consequently, many of them are highly technical. Their intended readers should find them extremely

useful. General readers will find much of interest, but some parts of the book will be very heavy going.

The book is beautifully produced, with an attractive colour reproduction of a late nineteenth-century pencil sketch of a forest scene on the cover.

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MISCELLANEOUS

Understanding DNA and Gene Cloning: A Guide for the Curious

By Karl Drlica. 1984. John Wiley, New York. xiii + 205 pp., illus. U.S.\$11.95.

The use of the word "clone" as a verb is relatively new. Dictionaries published as recently as the late sixties list it only as a noun derived from a Greek word meaning "twig" and signifying the progeny of a particular organism produced by asexual means, whether naturally or artificially. A clone was nothing more recondite than a culture of bacteria derived from a single isolate, or a number of geranium plants derived from a common ancestor by the rooting of slips. Now the word has entered everyday language, sometimes as a kind of metaphor for identical copies and sometimes as something vaguely sinister.

Gene cloning, as described by the author of this book, has nothing sinister about it. It is "a way to use microorganisms to produce millions of identical copies of a specific region of DNA." When the feasibility of introducing alien DNA into living bacteria was first recognized in the early seventies, the prospect aroused a good deal of apprehension. Many feared that such organisms could pose a threat to human health and the environment if they escaped from the laboratory. It now appears that the dangers were considerably overrated and that the procedure of gene cloning has much to contribute to human well-being, but the controversy which took place at that time may have helped to give the word "clone" some of the connotation it carries today.

The author of this book has not written a textbook for future molecular biologists, but rather a simple, though not oversimplified, account for the general reader. He begins with an outline of the basic concepts of molecular biology: transcription, translation, replication, the action of repressors. All these are succinctly but clearly described. There is also a short chapter on the techniques of culturing bacteria. The author then turns to gene cloning, how it is done, and why. The uses of such enzymes as restriction nucleases, DNA ligase, and reverse transcriptase are explained. The techniques used for such purposes as the isolation of the few bacterial cells containing a particular gene of interest from the millions that lack it, the separation of DNA fragments by gel electrophoresis, and the determination of nucleotide sequences in DNA are described.

The matters discussed in this book represent the greatest triumph of reductionist biology and one of the great intellectual achievements of our time. For me, it is impossible not to admire the elegance and ingenuity of the concepts and techniques which the author of this book describes so well. All those who are curious about DNA and gene cloning will find this a fascinating and dependable guide, and I recommend it to them.

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The Island of South Georgia

By Robert Headland. 1984. Cambridge University Press, New York. 293 pp., illus. U.S.\$39.50.

Many years ago I decided to apply for the position of station chemist at the whaling station, Leith Harbour, South Georgia. Fortunately for the whales, the station closed in the mid-1960s, as did all the others in South

Georgia, just about the time I went to university. Why would anyone want to go to a place once called "the slum of the Antarctic" — because it is a fascinating place with many impressive seabird colonies.

South Georgia has gone through four major phases. The first was the mania for exploration that began in

the eighteenth century. Then came the commercial phase where first seals and then whales were boiled down to provide oil and other products for the north. With the end of whaling, South Georgia became a peaceful, gentle place concerned with research. Recently, in 1982, it reached its most dangerous phase when it became part of the political issue of the Falklands war.

Robert Headland gives a very detailed history of all these four phases: exploration, commercial exploitation, research, and the war and its aftermath. He also covers the physical sciences of the land, the ocean and the climate. His section on natural history deals not only with the obvious birds, marine mammals, and plants, but also with aquatic invertebrates, fish and introduced mammals. He provides some useful insights into the effects of mammals introduced into a stable ecology.

The author devotes one chapter to communications — surely an important issue for a remote island. This includes a detailed history of the Post Office. Stamps issued by South Georgia itself or issued as part of the Falkland Island Dependencies are collectors' items, and generally depicted southern ocean specialities. Mammals, Antarctic crustacea, plants, and explorers with their boats are favourite subjects. Oddly, the magnificent seabirds have rarely been depicted.

The book is written in a very detailed and clinically scientific style. It seems that virtually every human, boat, dog, cat, or piece of machinery that reached South Georgia has been researched and documented

by the author. However, the author's rather cool and precise prose sadly loses some of the drama and emotion in many of South Georgia's tales. An account of scientific work need not be dry. (Read, for example, Apsely Cherry-Gerrard's *Worst Journey in the World*.) Shackleton's story must be one of the most gripping and soul stirring tales of exploration. In fact, the author is often so terse that we get only vague hints of his own contribution to South Georgia's history. For example, he clearly hoodwinked the Argentinian forces over postal records, but he never tells us his own story. He was taken prisoner (we are told so on the dust cover) and this was a terrifying (maybe adventurous) experience. He could have added much more human perspective to this episode.

Thus, there are many other books on this wonderful region that are more warmly written. There are books that give a better feel for the lot of the whaler and the whales they hunted, books written with such power that the reader can almost smell the nauseating stench of the whale factories. There are more delightful books on the area's unique wildlife. But no book contains as much information, precisely stated, about South Georgia. In addition, the author has included 80 black-and-white photographs that complement the text well. You cannot read this book without gaining a broad understanding of South Georgia and a respect for the author's knowledge.

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Montana's Explorers — The Pioneer Naturalists

By Larry S. Thompson. 1985. Montana Magazine Inc., Helena, Montana 59604. 109 pp., illus.

This book tells the story of the early naturalists who explored Montana during the period 1805-1864. These explorer-naturalists faced many hardships of wilderness travel, frequently including the loss of irreplaceable specimens, during a time when Montana was truly *terra incognita*. These men included Lewis and Clark, David Thompson, Prince Paul of Wurtemberg, Prince Maximilian of Weid, Nathaniel Wyeth, Charles Geyer, Joseph Burke, Father DeSmet, John Audubon, John Palliser, Thomas Blackiston and Ferdinand Hayden. The author contrasts the explorations of these men in Montana of the 1800s with current references to the biota of the same localities, and uses appropriate excerpts from the writings of the naturalists themselves throughout the text.

Maps are included which show their travels in Montana and in adjacent states and provinces; these maps are not detailed, but they are useful. One hundred

photographs and numerous paintings and sketches by the naturalists or their contemporaries greatly enhance the text. Many of the paintings are those of Karl Bodmer, who accompanied Prince Maximilian and was perhaps the greatest artist ever to work the Missouri River area, and of John Audubon, whose Montana explorations came at the end of his career.

By the 1860s Montana had become a territory, the discovery of gold brought settlement, great herds of bison and elk were depleted, and the great European naturalists of the earlier 1800s were a dying breed. An upcoming companion volume in this series will detail the post-1860s explorations, including the coming of the railroads, extermination of the bison, and the growing role of the federal government in scientific exploration. If its accounts are as interesting and informative as those in the current book, I look forward to its publication.

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NEW TITLES

Zoology

†**Advances in marine biology, volume 23.** 1986. Edited by J. H. S. Blaxter and A. J. Southward. Academic Press (Canadian distributor Harcourt Brace Jovanovich, Toronto). xi + 385 pp., illus. \$117.95.

Among predators and prey. 1986. By Hugo van Lawick. Sierra Club Books (Distributed by Random House, New York). 224 pp., illus. U.S.\$35.

†**Animals of the western rangeland: a test to survive and thrive.** 1986. By Ernest H. Elms. Naturegraph, Happy Camp, California. x + 221 pp., illus. Cloth U.S.\$14.95; paper U.S.\$8.95 plus U.S.\$1 postage.

Audubon wildlife report, 1986. 1986. By the National Audubon Society, New York. xiv + 1094 pp., illus. U.S.\$34.95.

***Auks: an ornithologist's guide.** 1987. By Ron Freethy. Facts on File, New York. 192 pp., illus. U.S.\$24.95; \$36.95 in Canada.

La biologie du suceur cuivré, *Moxostoma hubbsi*, une espèce rare et endémique à la région de Montréal, Québec, Canada. 1986. Par Jean-René Monglan, Pierre Dumont, et Louise Cloutier. Rapport Technique No. 06-29. Ministère du Loisir, de la Chasse, et de la Pêche, Québec. xxv + 137 pp., illus.

Birds of the Indiana dunes. 1986. By Kenneth J. Brock. Indiana University Press, Bloomington. xii + 178 pp., illus. Cloth U.S.\$25; paper U.S.\$7.95.

Bluebirds, their daily lives, and how to attract and raise bluebirds. 1987. By Tina Dew, Curtis Dew, and Reber B. Layton. Nature Books Publishers, Jackson, Mississippi. 222 pp., illus. + plates. U.S.\$9.95.

Bryozoa: Ordovician to recent. 1985. Edited by Claus Nielsen and Gilbert P. Larwood. From a conference, Vienna, July, 1983. Olsen and Olsen, Fredensborg, Denmark. vii + 364 pp., illus. U.S.\$85.

The butterflies of North America: a natural history and field guide. 1986. By James A. Scott. Stanford University Press, Stanford. xv + 583 pp., illus. U.S.\$49.50.

Current mammalogy, volume 1. 1987. Edited by Hugh H. Genoways. Plenum, New York. c515 pp. U.S.\$75.

†**Diving birds of North America.** 1987. By Paul A. Johnsgard. University of Nebraska Press, Lincoln. xii + 292 pp., illus. U.S.\$45.

Eggs: nature's perfect package. 1987. By Robert Burton, Kim Taylor, and Jane Burton. Facts on File, New York. 160 pp., illus. U.S.\$24.95; \$33.95 in Canada.

The encyclopedia of reptiles and amphibians. 1986. Edited by Tim Halliday and Kraig Adler. Facts on File, New York. 160 pp., illus. U.S.\$24.95; \$36.95 in Canada.

Females of the species: sex and survival in the animal kingdom. 1986. By Bettyann Kevles. Harvard University Press, Cambridge. xii + 270 pp., illus. U.S.\$20.

†**Foraging theory.** 1987. By David W. Stephens and John R. Krebs. Monographs in behavior and ecology. Princeton University Press, Princeton. xiv + 247 pp., illus. Cloth U.S.\$40; paper U.S.\$14.50.

†**Game management.** 1986. By Aldo Leopold. Reprint of 1933 edition. University of Wisconsin Press, Madison. xxxiv + 481 pp., illus. U.S.\$14.

†**Grand Canyon birds: historical notes, natural history, and ecology.** 1987. By Bryan T. Brown, Steven W. Carrothers, and R. Roy Johnson. University of Arizona Press, Tucson. c310 pp., illus. U.S.\$19.95.

Guide to watching whales in Canada. 1986. Canadian Government Publishing Centre, Ottawa. \$5.95 in Canada; \$7.15 elsewhere. English or French.

History of white whale (*Delphinapterus leucas*) exploitation in eastern Hudson Bay and James Bay. 1987. By Randall R. Reeves and Edward Mitchell. Canadian Government Publishing Centre, Ottawa. 45 pp., illus. \$5 in Canada; \$6 elsewhere.

***An introduction to behavioural ecology.** 1987. By J. R. Krebs and N. B. Davies. Second edition. Sinauer, Sunderland, Massachusetts. ix + 389 pp., illus. U.S.\$18.95.

Mammal evolution: an illustrated guide. 1986. By R. J. G. Savage and M. R. Long. Facts on File, New York. 264 pp., illus. U.S.\$35; \$50 in Canada.

The migration of hawks. 1986. By Donald S. Heintzelman. University of Indiana Press, Bloomington. 384 pp., illus. U.S.\$35.

The Mollusca, volume 9: neurobiology and behaviour, part 2. 1986. Edited by A. O. Dennis Willows. Academic Press, Orlando. xii + 499 pp., illus. U.S.\$85.

***The natural history of antelopes.** 1986. By C. A. Spinage. Facts on File, New York. xiii + 203 pp., illus.

***The natural history of butterflies.** 1986. By John Feltwell. Facts on File, New York. 134 pp., illus. U.S.\$19.95.

***The natural history of squirrels.** 1987. By John Gurnell. Facts on File, New York. 232 pp., illus. U.S.\$21.95; \$31.95 in Canada.

†**The natural history of whales and dolphins.** 1987. By Peter G. H. Evans. Facts on File, New York. 224 pp., illus. U.S.\$21.95.

On the track of ice age mammals. 1986. Antony J. Sutcliffe. Harvard University Press, Cambridge. 224 pp., illus. U.S.\$25.

The oyster: the life and lore of the celebrated bivalve. 1986. By Robert A. Hedeon. Tidewater, Centreville, Maryland. xii + 237 pp., illus. U.S.\$16.95.

Perspectives in ethology, volume 7: alternatives. 1987. Edited by P. P. G. Bateson and Peter H. Klopfer. Plenum, New York. c275 pp. U.S.\$42.50.

The pleasure of watching birds. 1986. By Lola Oberman. Prentice-Hall, New York. xvi + 256 pp., illus. U.S.\$17.95.

***Raptor conservation in the next 50 years.** 1986. By the Raptor Foundation. Raptor Research Reports No. 5. Press Publishing, Provo, Utah. vii + 87 pp., illus. U.S.\$4.50 plus shipping.

†**Sharks of the world.** 1986. By Rodney Steel. Facts on File, New York. 192 pp., illus. U.S.\$19.95; \$29.95 in Canada.

Snakes of the world. 1986. By Christopher Mattison. Facts on File, New York. 192 pp., illus. U.S.\$19.95; \$29.95 in Canada.

Songbirds in your garden: how to attract, feed, and enjoy birds in your garden or backyard. 1987. By John K. Terres. Fitzhenry and Whiteside, Markham. 288 pp., illus. \$15.95.

Song of the whale. 1986. By Rex Weyler. Anchor Press (Doubleday, Garden City, New York). xii + 273 pp. + plates. U.S.\$16.95.

Spiders, webs, behavior, and evolution. 1986. Edited by William A. Shear. Stanford University Press, Stanford. xiii + 492 pp., illus. U.S.\$55.

State birds. 1986. Text by Virginia Buckley, paintings by Arthur and Alan Singer. Lodestar (Canadian distributor Beaverbooks, Markham). 64 pp., illus. \$21.95.

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Waterfowl identification: the LeMaster method. 1986. By Richard LeMaster. Contemporary (Canadian distributor, Beaverbooks, Markham). 76 pp., illus. Cloth U.S.\$24.50; paper U.S.\$15.95.

Wildlife sketching: pen, pencil, crayon, and charcoal techniques. 1986. By Frank F. Lohan. Contemporary (Canadian distributor, Beaverbooks, Markham). 128 pp., illus. \$22.50.

A world list of mammalian species. 1986. By G. B. Corbett and J. E. Hill. Facts on File, New York. 256 pp. U.S.\$29.95; \$43.95 in Canada.

***A world of watchers.** 1986. By Joseph Kastner. Knopf, New York. 241 pp., illus. U.S.\$36.75.

Botany

The cactus primer. 1986. By Arthur C. Gibson and Park S. Nobel. Harvard University Press, Cambridge. x + 286 pp., illus. U.S.\$39.95.

†**Cell culture and somatic genetics of plants, volume 3: plant regeneration and genetic variability.** 1986. Edited by Indra K. Vasii. Academic Press (Distributed in Canada by Harcourt Brace Jovanovich, Don Mills). xix + 657 pp., illus. \$129.95.

Floristic regions of the world. 1986. By Armen Takhtajan. Translated from Russian by Theodore J. Crovello. University of California Press, Berkeley. xxii + 522 pp. U.S.\$60.

A garden of wildflowers. 1986. By Henry W. Art. Gardening Publishing, Pownal, Vermont. 290 pp. Cloth U.S.\$22.50; paper U.S.\$12.95.

†**Mineral nutrition of higher plants.** 1986. By Horst Marschner. Academic Press (Distributed in Canada by Harcourt Brace Jovanovich, Don Mills). xii + 674 pp., illus. \$138.75.

***The origin and domestication of cultivated plants.** 1986. Edited by C. Barigozzi. Proceedings of a symposium, Rome, 26-27 November, 1985. Elsevier, New York. vi + 228 pp. U.S.\$71.

Plants for shade and woodlands. 1987. By Allen Patterson. Fitzhenry and Whiteside, Markham. 244 pp., illus. \$15.

Seed dispersal. 1986. By David R. Murray. Academic Press (Canadian distributor, Harcourt Brace Jovanovich, Don Mills). 330 pp.

A Sierra Nevada flora. 1986. By Norman F. Weeden. Third edition. Wilderness Press, Berkeley. vi + 406 pp., illus. U.S.\$10.95.

***A Utah flora.** 1987. Edited by Stanley L. Welsh, N. Duane Atwood, Sherel Goodrich, and Larry C. Higgins. Great Basin Naturalist Memoirs No. 9. 894 pp. U.S.\$40.

Wildflower gardener's guide: northeast, mid-Atlantic, Lake states, and eastern Canada edition. 1987. By Henry W. Art. Fitzhenry and Whiteside, Markham. 160 pp., illus. Cloth U.S.\$31.50; paper U.S.\$15.95.

Environment

Advances in ecological research, volume 15. 1986. Edited by A. MacFayden and E. D. Ford. Academic Press (Canadian distributor, Harcourt Brace Jovanovich, Don Mills). 448 pp. U.S.\$68.

†**American sportsmen and the origins of conservation.** 1986. By John F. Reiger. Revised edition. University of Oklahoma Press, Norman. 316 pp., illus. U.S.\$11.95.

Conservation biology: the science of scarcity and diversity. 1986. Edited by Michael E. Soule. Sinauer, Sunderland, Massachusetts. 480 pp., illus. Cloth U.S.\$46.50; paper U.S.\$27.

Contemporary classics in plant, animal, and environmental sciences. 1986. Compiled by James T. Barrett. ISI Press, Philadelphia. xv + 371 pp. U.S.\$39.95.

Earth: the stuff of life. 1986. By Firman E. Bear. Second edition, revised by H. Wayne Pritchard and Wallace E. Akin. University of Oklahoma Press, Norman. Illus. U.S.\$19.95 + U.S.\$1.50 postage.

Ecology: individuals, populations, and communities. 1986. By Michael Begon, John L. Harper, and Colin R. Townsend. Sinauer, Sunderland, Massachusetts. 439 pp., illus. U.S.\$33.95.

Environmental policy in the U.S.S.R. 1987. By Charles E. Zeigler. University of Massachusetts Press, Amherst. 216 pp., illus. U.S.\$25.

Envirosoft 86. 1986. Edited by Paolo Zannetti. Proceedings of an international conference on development and application of computer techniques to environmental studies, Los Angeles, November, 1986. Computational Mechanics Publications, Boston. 809 pp.

European environmental yearbook. 1987. By various authors. DocTer, London. c800 pp., illus. £45.

Field guide to forest ecosystems of west-central Alberta. 1986. By I. G. W. Corns and R. M. Annas. Canadian Forestry Service, Edmonton. 251 pp., illus. Free.

The forgotten peninsula: a naturalist in Baja California. 1986. By Joseph Wood Krutch. University of Arizona Press, Tucson. xiv + 277 pp. U.S.\$9.95.

***Handbook of the Canadian Rockies: geology, plants, animals, history, and recreation from Waterton/Glacier to the Yukon.** 1986. By Ben Gadd. Corax Press, Jasper, Alberta. 896 pp., illus. \$25.

Key environments: Malaysia. 1987. Edited by the Earl of Cranbrook. Pergamon Press, New York. c350 pp., illus. U.S.\$33.

Mathematical ecology: an introduction. 1986. Edited by Thomas G. Hallan and Simon A. Levin. Springer-Verlag, New York. xii + 457 pp., illus. U.S.\$80.

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Resolving environmental disputes: a decade of experience. 1986. By Gail Bingham. The Conservation Foundation, Washington. xxviii + 284 pp. U.S.\$15.

The savannas. 1986. By Monica Cole. Academic Press (Canadian distributor, Harcourt Brace Jovanovich, Don Mills). 456 pp. U.S. \$79.50.

These American lands: parks, wilderness, and public lands. 1986. By Dyan Zaslowsky. Henry Holt, New York. xii + 404 pp., illus. U.S.\$22.95.

Waterlogged wealth: why waste the earth's wet places? 1986. By Edward Maltby. International Institute for Environment and Development, Washington. 200 pp., illus. U.S.\$7.75.

***The wet boglands: Bellamy's Ireland.** 1987. By David Bellamy. Facts on File, New York. 178 pp., illus. U.S.\$19.95; \$29.95 in Canada.

World enough and time: successful strategies for resource management. 1986. By Robert Repetto. Yale University Press, New Haven. xiv + 147 pp. Cloth U.S.\$16; paper U.S.\$5.95.

Miscellaneous

Evolutionary biology, volume 21. 1987. Edited by Max K. Hecht, Bruce Wallace, and Ghilleen T. Prance. Plenum, New York. c425 pp. U.S.\$59.50.

Evolution as entropy: toward a unified theory of biology. 1986. By Daniel R. Brooks and E. O. Wiley. University of Chicago Press, Chicago. 350 pp., illus. U.S.\$25.

Evolution through group selection. 1986. By V. C. Wynne-Edwards. Blackwell Scientific, Boston. xii + 386 pp., illus. Cloth U.S. \$58; paper U.S. \$29.

Georgia wetlands: trends and policy options. 1986. By James E. Kundell and S. Wesley Woolf. University of Georgia, Athens. viii + 112 pp., illus. U.S.\$10.95.

The last extinction. 1986. Edited by Les Kaufman and Ken Mallory. MIT Press, Cambridge. U.S.\$16.95.

Life pulse: episodes from the story of the fossil record. 1987. By Niles Eldredge. Facts on File, New York. 288 pp., illus. U.S.\$19.95.

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Principles and methods of reclamation science: with case studies from the arid southwest. 1986. Edited by Charles C. Reith and Loren D. Potter. University of New Mexico Press, Albuquerque. xx + 224 pp., illus. Cloth U.S.\$30; paper U.S.\$17.50.

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Books for Young Naturalists

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Discovering butterflies and moths. 1986. By Wendy Meadow. Bookwright, New York. 467 pp., illus. U.S.\$10.40.

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Dive to the coral reefs. 1986. By Elizabeth Tayntor, Paul Erikson, and Les Kaufman. Crown, New York. 36 pp., illus. U.S.\$12.95.

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Eye on nature: a photographer's introduction to familiar wildlife. 1986. By George Laycock. Prentice-Hall, Englewood Cliffs, New Jersey. xii + 162 pp., illus. U.S.\$9.95.

Fireflies. 1986. By Sylvia A. Johnson. Lerner, Minneapolis. 48 pp., illus. U.S.\$12.95.

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From living cells to dinosaurs. 1986. By Roy A. Gallant. Watts, New York. 96 pp., illus. U.S.\$9.90.

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How to think like a scientist: answering questions by the scientific method. 1987. By Stephen P. Kramer. Crowell (Canadian distributor, Fitzhenry and Whiteside, Markham). 48 pp., illus. \$18.50.

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Meet the beaver. 1986. By Leonard Lee Rue, III. Dodd, Mead, New York. 78 pp., illus. U.S.\$10.95.

The microscope. 1986. By Maxine Kumin. Harper (Canadian distributor, Fitzhenry and Whiteside, Markham). 32 pp., illus. \$4.95.

Mosquitos. 1986. By Dorothy Hinshaw Patent. Holiday House, New York. 40 pp., illus. U.S.\$11.95.

A night in the swamp: a moveable book. 1987. By Thacher Hurd. Carousel (Canadian distributor Fitzhenry and Whiteside). 12 pp., illus. \$12.95.

100 dinosaurs from A to Z. 1986. By Ron Wilson. Grosset (Canadian distributor, Beaverbrooks, Markham). 64 pp., illus. \$12.95.

On the trail of the fox. By Claudia Schnieper. Carolrhoda, Minneapolis. 48 pp., illus. U.S.\$12.95.

Rock collecting. 1987. By Roma Gans. Harper (Canadian distributor, Fitzhenry and Whiteside). 32 pp., illus. \$5.95.

Secrets in the meadow. 1986. By Lilo Hess. Scribner's, New York. 64 pp., illus. U.S.\$13.95.

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Star guide. 1987. By Franklin M. Branley. Crowell (Canadian distributor: Fitzhenry and Whiteside, Markham). 64 pp., illus. \$18.50.

The story of life on earth: tracing its origins and development through time. 1986. By Michael Benton. Warwick, New York. 93 pp., illus. U.S.\$13.90.

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Tree frogs. 1986. By Sylvia A. Johnson. Lerner, Minneapolis. 48 pp., illus. U.S.\$12.95.

Volcanoes and earthquakes. 1986. By Martyn Bramwell. Watts, New York. 32 pp., illus. U.S.\$9.90.

Year at Elk Mountain. 1986. By Jackie Gilmore. Roberts Rinehart, Boulder, Colorado. 16 pp., illus. U.S.\$3.95.

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